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For arrangement of subjects and authors see page v.

MORRIS'S

HUMAN ANATOMY

A COMPLETE SYSTEMATIC TREATISE BY ENGLISH AND AMERICAN AUTHORS

EDITED BY

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THREE HUNDRED AND NINETEEN PRINTED IN COLORS

FOURTH EDITION, REVISED AND ENLARGED

IN FIVE PARTS

PART IV

THE ORGANS OF DIGESTION. THE RESPIRATORY ORGANS. THE URINARY AND REPRODUCTIVE ORGANS. THE DUCTLESS GLANDS. THE SKIN AND MAMMARY GLANDS

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ARRANGEMENT OF SUBJECTS AND AUTHORS.

The names of those who originally wrote articles and those who revised and wrote for previous editions have been retained in the following list of contents, in order that due credit should be given them for the work done and for their share in the great success which Morris's "Anatomy" has achieved throughout England and America.

MORPHOGENESIS. (The Development of Structure.) By J. PLAYFAIR McMURRICH, A.M., PH.D., Professor of Anatomy, University of Michigan; Member Association of American Anatomists; Member of Advisory Board, Wistar Institute of Anatomy; Member of Editorial Board of "American Journal of Anatomy;" Author of "The Development of the Human Body."

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ORGANS OF SPECIAL SENSE. Eye.—By R. MARCUS GUNN, F.R.C.S., Senior Surgeon, Royal London Ophthalmic Hospital (Moorfields); Surgeon to the Western Ophthalmic Hospital and to the National Hospital for the Paralysed and Epileptic. Ear, Nose, Tongue.—By ABRAM T. KERR, B.S., M.D., Professor of Anatomy, Cornell University; Member Association of American Anatomists. The sections on Ear, Nose, Tongue in previous editions were written by the late Arthur Hensman, F.R.C.S., and revised by Arthur Robinson, M.D., Professor of Anatomy, University of Birmingham.

ORGANS OF DIGESTION. Revised by G. CARL HUBER, M.D., Professor of Histology and Embryology in the University of Michigan; Secretary Association of American Anatomists; Member of Advisory Board, Wistar Institute of Anatomy; Member of Editorial Board of "American Journal of Anatomy." This article was originally written by Sir Frederick Treves, K.C.V.O., F.R.C.S.

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URINARY AND GENERATIVE ORGANS. Revised by J. PLAYFAIR MCMURRICH, A.M., PH.D., Professor of Anatomy, University of Michigan; Member Association of American Anatomists. This section includes "The Perineum," by Peter Thompson, M.D. These articles were originally written by the late William Anderson, F.R.C.S., formerly Vice-President Anatomical Society of Great Britain.

THE DUCTLESS GLANDS, INCLUDING THE THYREOID GLAND. By G. CARL HUBER, M.D., Professor of Histology and Embryology in the University of Michigan; Secretary Association of American Anatomists.

THE SKIN AND MAMMARY GLAND. By ABRAM T. KERR, B.S., M.D., Professor of Anatomy, Cornell University; Member Association of American Anatomists, etc. This article was originally written by the late William Anderson, F.R.C.S., formerly Vice-President Anatomical Society of Great Britain.

SURGICAL AND TOPOGRAPHICAL ANATOMY. By W. H. A. JACOBSON, F.R.C.S., Consulting Surgeon to Guy's Hospital; formerly Lecturer on Anatomy, Guy's Hospital Medical School; Author of "The Operations of Surgery," etc.

ABSTRACT OF PUBLISHERS' NOTE

AS PRINTED IN PART I

The very favorable reception accorded the previous editions of this work in America suggested the desirability of making the present (fourth) edition international in its character, by placing it largely in the hands of an American editor and by securing the services of American Anatomists in the revision or rewriting of certain of the sections.

The entire work has undergone a complete revision, and some sections have been entirely rewritten and, in several instances, considerably enlarged; the text has been brought thoroughly up to date by the inclusion of the results of recent investigations, and represents, accurately, the present state of Anatomy. Many illustrations which appeared in previous editions have been omitted, a large number of new figures have been made from specially prepared drawings, and pictures from other books have been included where they served the desired purpose.

Special attention should be directed to the use throughout the volume of the nomenclature adopted by the German Anatomical Society and generally known as the Basle nomenclature, or BNA. In employing this nomenclature the editors have been guided by a desire to assist in the unification of anatomical terminology, seeing in such unification an earnest of the thorough internationalization of the science of anatomy and more rapid progress in its development. The modifications of the accepted English nomenclature necessitated by the adoption of the BNA are comparatively few, and where they are radical, the more familiar terms have been added in parentheses. Whilst this is the first text-book of Anatomy in English to adopt the BNA in its entirety, there are a number of books and papers on Embryology, Histology, and Biology in which it is used; its general adoption in the future, it may be confidently expected, will be assured. In this connection, reference should be made to a new book by Prof. Llewellys F. Barker, of Johns Hopkins University, in which a complete list of the terms used in the BNA is given and in which the object, system, and practicability of the nomenclature are explained.

Each author is alone responsible for the subject-matter of the article following his name. Care has been exercised on the part of the editors, however, to make the whole uniform, complete, and systematic.

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Revised by G. Carl Huber, M.D.

SECTION IX

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Originally Written by Arthur Hensman, F.R.C.S., and Arthur Robinson, M.D., F.R.C.S.

Rewritten for the Fourth Edition by R. J. Terry, A.B., M.D.

SECTION X

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Originally Written by William Anderson, F.R.C.S.

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REVISED BY G. CARL HUBER, M.D.

SECTION XII

THE SKIN AND MAMMARY GLANDS

ORIGINALLY WRITTEN BY WILLIAM ANDERSON, F.R.C.S

REVISED AND LARGELY REWRITTEN FOR THE FOURTH EDITION BY ABRAM T. KERR, B.S., M.D.

The mode of describing illustrations which has been carried out as far as practicable consists in printing the descriptions in different types at the end of the pointers. Thus, the **muscles, fascia, and ligaments** are in one kind of type; *arteries, veins, and lymphatics* in another; BONES AND SPECIAL ORGANS in a third; *NERVE STRUCTURES* in a fourth.

SECTION VIII

THE ORGANS OF DIGESTION

By Arthur Hensman, F.R.C.S., and Sir Frederick Treves, K.C.V.O., F.R.C.S.Eng.

Revised by

G. CARL HUBER, M.D.,

Professor of Histology and Embryology in the University of Michigan

THE MOUTH

THE oral cavity represents the commencement of the alimentary canal and contains the organs of taste and mastication and the greater part of those of speech, serving also as a passage for the respired air. It communicates with the exterior through a transverse orifice, the oral fissure, and with the pharynx through the isthmus of the fauces.

The oral cavity is bounded anteriorly and laterally by the teeth and alveolar arches, external to which is a second cavity known as the **oral vestibule,** which is enclosed by the lips and cheeks. Its roof is formed by the hard palate, its floor by the tongue, with the mucous membrane reflected from it to the inner surface of the gums over the sublingual glands and the submaxillary ducts (Wharton's ducts); and posteriorly it opens into the fauces. It is lined by mucous membrane, which is continuous with that of the pharynx, and through the oral vestibule is continuous, at the outer margin of the lips, with the skin.

The **oral fissure** is a horizontal slit, the extremities or 'angles' of which are opposite the first bicuspid teeth. The fissure is bounded by the **upper** and **lower lips,** of which the former is distinguished by a median tubercle, the remains of the free extremity of the fronto-nasal process. The **lips** are covered by a dry mucous membrane, bright red in colour, and extremely sensitive, containing large numbers of vascular papillæ, in many of which are nerve-terminations resembling tactile corpuscles. Near to the junction of the skin and mucous membrane are numerous sebaceous follicles, but these are devoid of hair-bulbs.

The substance of the lips consists of the orbicularis oris and a quantity of areolar tissue in which are embedded the inferior and superior labial (coronary) arteries, lymphatics, and small branches of the infraorbital and mental nerves. Around the orifice of the mouth on its inner aspect, and placed beneath the mucous membrane, are a number of small lobulated glands known as the 'labial glands.'

The **cheek** consists of the buccinator muscle, covered externally, first by a stratum of subcutaneous fat, then by the dermal muscles, zygomaticus and risorius, and lastly by the skin. They are lined with mucous membrane, which contains numerous buccal glands similar to, but smaller than, the labial glands. Between the integument and the buccinator, in each cheek, besides vessels and nerves, there are several glands, the molar glands, whose ducts pierce the buccinator and open in the vestibule opposite the last molar teeth, and a large quantity of fat, which gives rotundity to the features, and constitutes what is sometimes spoken of as the 'sucking cushion' of the cheek. Opposite the second upper molar tooth is a papilla which marks the opening of the parotid duct (Steno's duct).

The development of the oral cavity.—The oral cavity has its origin in a depression, the **oral fossa,** situated between the ventrally bent, developing head and the region occupied by the developing heart. This fossa is bounded anteriorly by the fronto-nasal process, and laterally by the maxillary and mandibular processes, portions of the first branchial arches. The fossa

is lined by ectoderm. Its floor is in apposition with the cephalic end of the archenteron, lined by entoderm, the ectoderm of the oral fossa and the entoderm of the archenteron being in immediate contact and forming the **pharyngeal membrane.** The oral fossa deepens with further development, and becomes the oral sinus. The pharyngeal membrane becomes perforated during the third week of development and disappears, leaving a free communication between the oral sinus and archenteron. On each side of the developing head and in a latero-ventral position there is early developed an area of thickened ectoderm, known as the nasal area. These areas soon develope into depressions, the nasal fossæ, and assume a position, one to either side of the fronto-nasal process, on each side of the median line of which there is developed a prominent protuberance, the globular processes, each process forming the median wall of a nasal fossa. The lateral wall of each nasal fossa also thickens to form the lateral nasal process. With the further development, the ventral portion of each lateral nasal process fuses with the respective globular process, the maxillary processes also uniting with the globular processes, in this way separating externally the nasal fossæ from the oral sinus, the former communicating with the latter posterior to the maxillary processes. With the further growth towards the median line of the maxillary processes the fronto-nasal process becomes narrower, ultimately forming the nasal septum and a small median portion of the upper jaw, the remainder of the upper jaw being formed by the

FIG. 773.—FACE OF HUMAN EMBRYO OF ABOUT TWENTY-EIGHT DAYS. (His.) (After Kallius.)

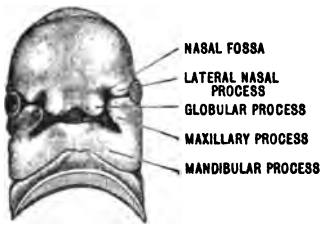
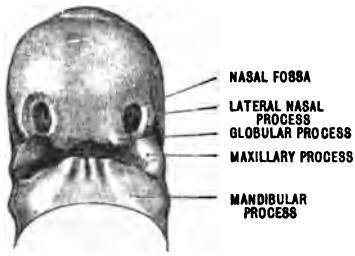


FIG. 774 —FACE OF HUMAN EMBRYO OF ABOUT THIRTY DAYS. (After Kallius.)



maxillary processes, and the lower jaw having its origin in the mandibular processes. During the first week of the second month in the development of the human embryo ledges of epithelium grow into the substance of the mandibular and the fused fronto-nasal and maxillary processes. These ledges develope into grooves which separate the lower and upper lips from the lower and upper jaws, the grooves forming the oral vestibule.

A want of union of the globular processes and the maxillary processes presents an arrest of development generally known as 'hare-lip.'

The **gums** are formed by a layer of dense areolar tissue covering the alveolar processes, and firmly attached to their periosteum. They are covered on both aspects by the mucous membrane of the mouth, the inner surfaces receiving reflexions from the sides and anterior extremity of the tongue, a median fold forming the frenulum of that organ; and the outer surfaces receiving reflexions from the cheeks and lips. In the median line above and below the orifice of the mouth are folds of mucous membrane, forming the frenulum of the upper and lower lips, of which the upper is the more marked.

THE PALATE

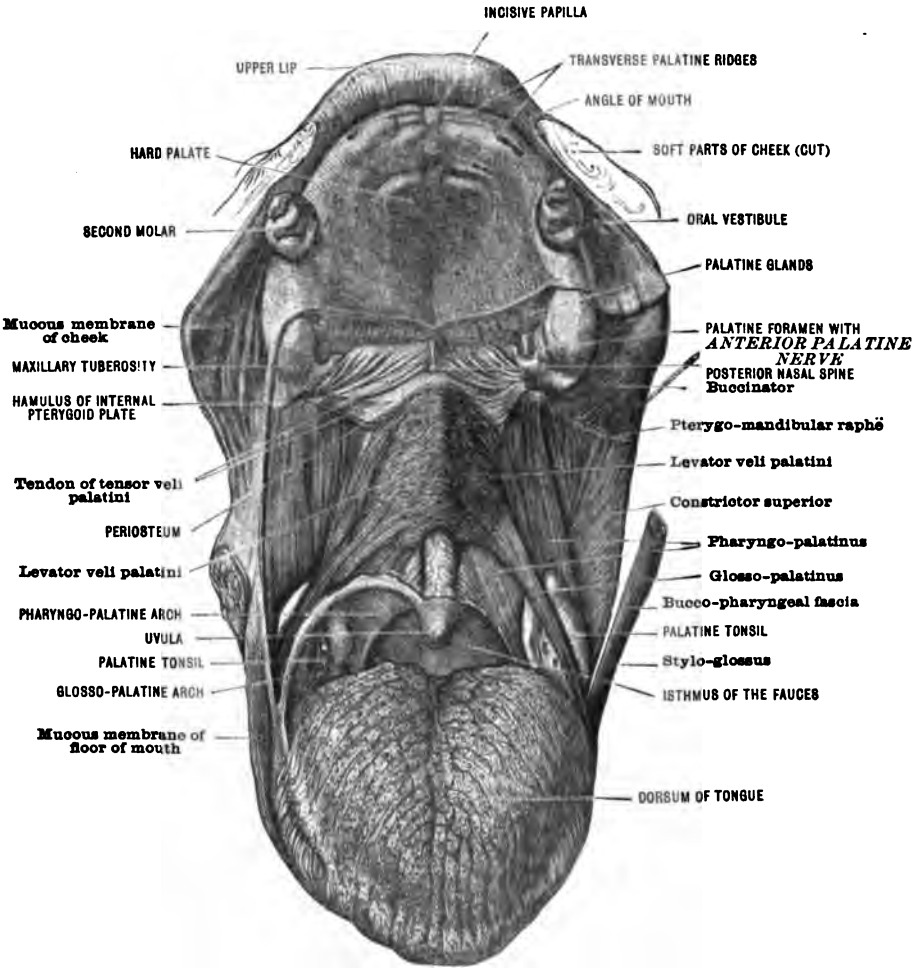
The **palate** consists of two portions, the anterior or hard palate, and the posterior or soft palate.

The **hard palate,** which is limited in front and laterally by the alveolar processes, ends posteriorly in a free border to which the soft palate is attached. It is curved from side to side, as well as from before backwards.

The mucous membrane which covers it is corrugated, thick, and somewhat pale, and is firmly bound down to its periosteum. In the median line of the palate is a ridge called the raphé; at the anterior extremity of this is a small papilla, the **incisive papilla,** which marks the opening of the incisive foramen (anterior palatine canal), and extending from its sides, anteriorly, are five or six transverse ridges. The mucous membrane covering the hard palate receives its nerve-supply from the anterior palatine and naso-palatine nerves. In it are found the palatine glands, larger and more numerous in the lateral portions.

The **soft palate** (fig. 775) is attached to the posterior border of the hard palate, of which it forms a backward prolongation, and extends backwards and downwards as the **velum of the palate,** which ends in a free border and partially separates the oral from the pharyngeal cavity. Lateralwards it merges with the pharyngeal wall, forming the **pharyngo-palatine** or **posterior palatine arches,** with backward and downward direction, and enclosing the pharyngo-palatine muscle; from the centre of the free border depends a somewhat conical projection, the **uvula.** From the oral surface of the velum of the palate, near the base of the uvula, there arise two folds of mucous membrane which extend lateralwards, downwards, and forwards, passing to the sides of the root of the tongue, forming the **glosso-palatine** or **anterior palatine**

FIG. 775.—THE MUSCLES OF THE SOFT PALATE AND THE PALATAL ARCHES AS SEEN FROM IN FRONT. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)



arches, and enclosing the glosso-palatine muscle. Between the anterior and posterior palatine arches is situated the tonsillar recess, containing the palatine tonsil.

The space between the anterior arches is known as the **isthmus of the fauces,** and forms the oral opening of the pharynx. It is bounded below by the tongue, above by the soft palate, and laterally by the arches of the fauces.

The **anterior surface of the soft palate** is concave, directed forwards and downwards, and is continuous with the lower surface of the hard palate; its **posterior surface,** which is convex, is a continuation of the floor of the nasal cavity, and it forms a part of the anterior wall of the pharynx.

Structure.—The soft palate is a fold of mucous membrane enclosing an aponeurosis, muscles, vessels, and nerves. It is marked in the middle line by a raphé indicating the line of junction of the two halves from which it was formed.

The posterior layer of the mucous fold which is directed towards the cavity of the pharynx is continuous with the nasal mucous membrane; the anterior layer lies in the posterior boundary of the mouth and is continuous with the mucous membrane of the hard palate; the lower margin is free. Glands are numerous in both layers, but more especially in the anterior.

The aponeurosis is attached above to the posterior margin of the hard palate; laterally it is continuous with the aponeurotic layer of the pharyngeal wall; below, towards the lower margin of the soft palate, it gradually disappears, and it gives attachment to fibres of the levator veli palatini and the pharyngo-palatinus (palato-pharyngeus) and to the tendon of the tensor veli palatini.

The muscles are arranged in layers either behind or in front of the aponeurosis, and in a horizontal section of the soft palate the following layers are met with from behind forwards:—(1) The mucous membrane on the pharyngeal surface; (2) the posterior layer of the pharyngo-palatinus (palato-pharyngeus); (3) the m. uvulæ; (4) the levator veli palatini; (5) the anterior layer of the pharyngo-palatinus; (6) the palatal aponeurosis with the tensor veli palatini; (7) the glosso-palatinus (palato-glossus); and (8) the mucous membrane on the oral aspect.

The **glosso-palatinus** (palato-glossus) is a cylindrical muscle extending between the soft palate and the lateral border of the tongue. *Origin.*—From the oral surface of the palatal aponeurosis. *Insertion.*—(1) The superficial layer of muscles which covers the side and adjacent part of the under surface of the tongue; (2) the transversus linguæ. *Structure.*—At its origin the muscle forms a thin sheet, but the fibres, passing outwards, quickly concentrate to form a cylindrical bundle, which passes downwards beneath the mucous membrane of the pharynx and in front of the tonsil, forming the glosso-palatine arch of the fauces. It reaches the side of the tongue at the junction of its middle and posterior thirds, and some of its fibres continue forwards to join with those of the stylo-glossus and hyo-glossus, while the majority pass medially to become continuous with the transversus linguæ. *Nerve-supply.*—From the pharyngeal branch of the vagus. *Action.*—(1) To draw the sides of the soft palate downwards; (2) to draw the sides of the tongue upwards and backwards. The combination of these actions tends to constrict the faucial isthmus.

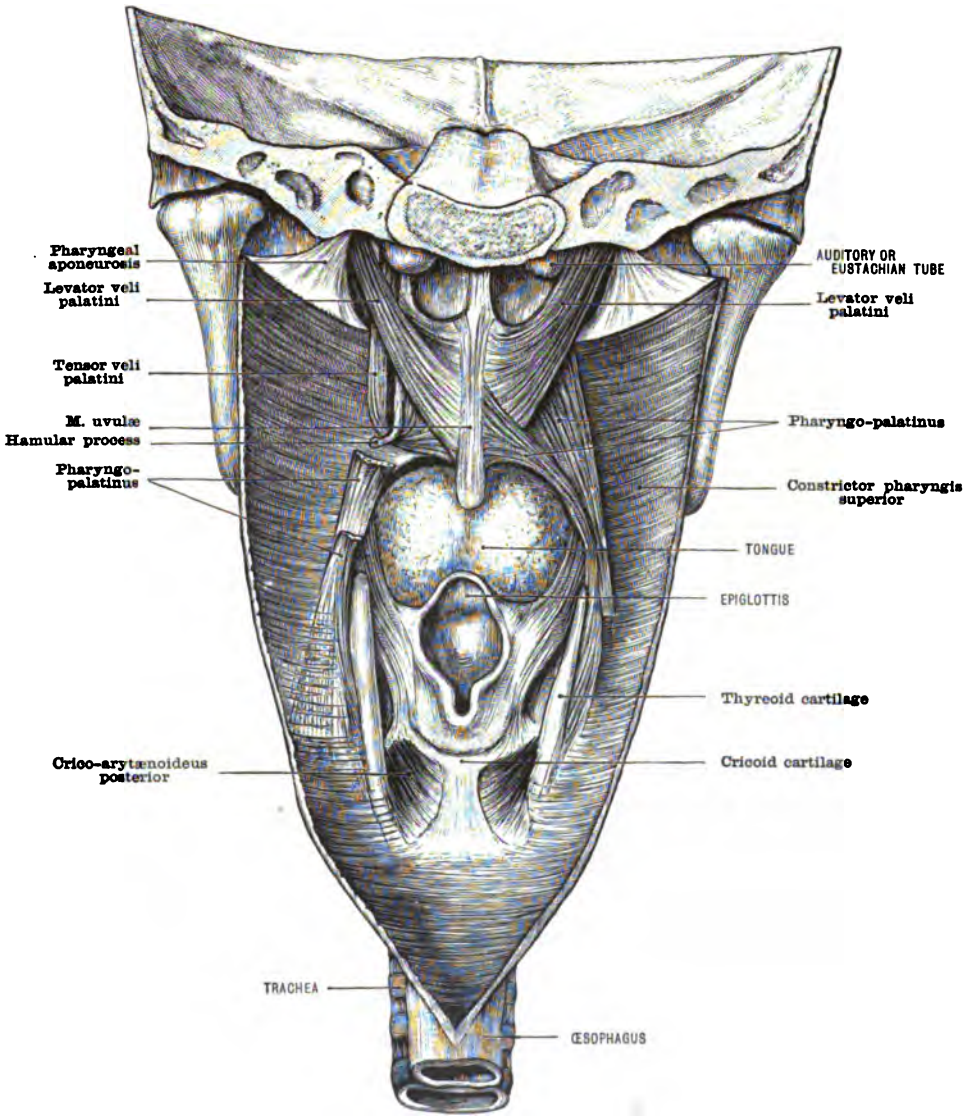
The **pharyngo-palatinus** (palato-pharyngeus)—named from its attachments—is a thin sheet. *Origin.*—(1) From the aponeurosis of the soft palate by two heads which are separated by the insertion of the levator levi palatini; (2) by one or two narrow bundles from the lower part of the cartilage of the auditory (Eustachian) tube (*salpingo-pharyngeus*). *Insertion.*—(1) By a narrow fasciculus into the posterior border of the thyreoid cartilage near the base of the superior cornu; (2) by a broad expansion into the fibrous layer of the pharynx at its lower part. *Structure.*—The upper head of the muscle consists of scattered fibres which blend with the opposite muscle across the middle line; the lower head is thicker, and follows the curve of the posterior border of the palate. The two heads with the fasciculus from the auditory (Eustachian) tube form a compact muscular band in the posterior palatine arch; the fibres mingle with those of the stylo-pharyngeus, at the lower border of the superior constrictor, and then expand upon the lower part of the pharynx. *Nerve-supply.*—From the pharyngeal branch of the vagus. *Action.*—(1) Approximates the posterior arches of the fauces; (2) depresses the soft palate; (3) elevates the pharynx and larynx.

The **levator veli palatini**—named from its action on the velum of the soft palate—is somewhat rounded in its upper, but flattened in its lower, half. *Origin.*—(1) The under surface of the petrous portion of the temporal, anterior to the orifice of the carotid canal; (2) the lower margin of the cartilage of the auditory (Eustachian) tube. *Insertion.*—The aponeurosis of the soft palate; the terminal fibres of the muscles of each side meet in the middle line in front of the m. uvulæ. *Structure.*—Its origin is by a short tendon; the muscle then becomes fleshy, and continues so to its insertion. *Nerve-supply.*—From the pharyngeal branch of the vagus. *Action.*—(1) To raise up the velum of the soft palate, and bring it in contact with the posterior wall of the pharynx; (2) to narrow the pharyngeal opening and to widen the isthmus of the auditory (Eustachian) tube. (According to Cleland, it closes the pharyngeal opening of this tube.)

The **tensor veli palatini**—named from its action on the velum of the soft palate—is a thin, flat, and narrow sheet. *Origin.*—(1) The scaphoid fossa of the sphenoid; (2) the angular spine of the sphenoid; (3) the outer side of the membranous and cartilaginous wall of the auditory (Eustachian) tube. *Insertion.*—(1) Into the transverse ridge on the under surface of the horizontal plate of the palate bone; (2) the aponeurosis of the soft palate.

Structure.—Its belly as it descends between the pterygoideus internus and the internal pterygoid plate is muscular. On approaching the hamular process it becomes

FIG. 776.—VIEW OF MUSCLES OF SOFT PALATE, AS SEEN FROM WITHIN THE PHARYNX. (Modified from Bourgery.)



tendinous, and continues so to its insertion. A bursa is interposed between the hamular process and the tendon. The belly of the muscle is at nearly a right angle with its tendon. *Nerve-supply.*—From the mandibular division of the trigeminus through the tensor palati branch of the otic ganglion. *Actions.*—(1) Tightens the soft palate; (2) opens the auditory (Eustachian) tube during deglutition.

The **m. uvulæ**—so named by reason of its position in the uvula. *Origin.*—(1) From the aponeurosis of the soft palate and tendinous expansions of the two tensores

veli palatini. *Insertion.*—Into the uvula. *Structure.*—The muscle consists of two narrow parallel strips lying on each side of the middle line of the palate. *Nerve-supply.*—From the pharyngeal branch of the vagus. *Action.*—To draw up the uvula.

The **mucous membrane of the soft palate** is continuous with that of the mouth on its anterior aspect, and with that of the nasal chamber on its posterior surface; its epithelium is columnar and ciliated in the vicinity of the Eustachian tube, but elsewhere it is squamous and not ciliated. The **glands** form an especially thick layer in its upper portion on the oral surface.

Arterial supply of the soft palate.—(1) Ascending palatine of external maxillary (facial); (2) pharyngeal branches of ascending pharyngeal; (3) twigs from descending palatine of internal maxillary, which enter the smaller palatine canals, are distributed to the soft palate and tonsils, and communicate with the ascending palatine of the external maxillary (facial) artery; (4) lingual artery, by twigs from the dorsal branch.

Nerves to the soft palate.—(1) Branches from spheno-palatine (Meckel's) ganglion—posterior and median palatine branches; (2) tonsillar branches of glosso-pharyngeal nerve; and (3) the nerves supplying the muscles.

The **tonsils** (figs. 775, 780) are two ovoid bodies situated one in each of the recesses between the anterior and posterior arches of the fauces and beneath a small fossa, the **supratonsillar fossa,** which is the remains of the second branchial cleft. This is occasionally closed, internally, by a small fold of mucous membrane, the plica triangularis. They vary from 20 to 25 mm. in length, and from 12 to 15 mm. in width and thickness; but their size is liable to considerable variation. On their inner surfaces are a number of puncture-like openings (twelve to fifteen on each tonsil), which form the orifices of small recesses or crypts. The mucous membrane is continued into, and forms a lining for, these crypts; their walls are surrounded by an aggregation of lymph-nodules, similar to the solitary glands of the intestine.

The tonsil corresponds in position with the angle of the jaw; it is in relation externally with the superior constrictor of the pharynx, which separates it from the external maxillary (facial) artery; about 2·5 cm. externally and posteriorly to it is the internal carotid artery, and still more externally the internal pterygoid muscle.

The **arteries of the tonsil** are five in number, viz.:—(1) Dorsalis linguæ from the lingual; (2) ascending pharyngeal from the external carotid; (3) ascending palatine from the external maxillary (facial); (4) tonsillar from the external maxillary (facial); and (5) descending palatine from the internal maxillary.

The **veins of the tonsil** form a plexus which lies upon the outer side of the gland, and opens externally into the pharyngeal plexus.

The **lymphatics of the tonsil** communicate with those of the dorsum of the tongue, and they pass to a node which lies near the angle of the jaw.

The **nerves of the tonsil** are branches of the fifth and glosso-pharyngeal.

The development of the palate.—The hard and soft palate have their origin in two ridges of tissue, designated the **palate shelves,** which develope on the inner surfaces of the maxillary processes. These shelves grow towards the median line, and at the beginning of the third month of fœtal life meet beneath the nasal septum, uniting with each other and with the nasal septum, the union taking place from before backwards. The incisive foramen indicates the place of meeting of the premaxillary and palate shelves. A want of union of the palate shelves presents an arrest of development known as cleft-palate.

THE SALIVARY GLANDS

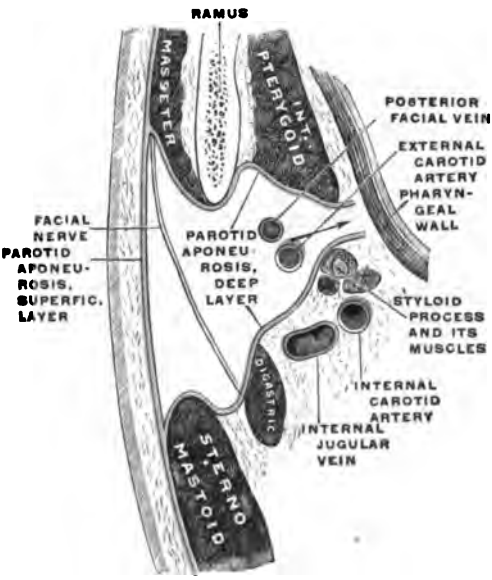
The three chief salivary glands are the **parotid,** the **submaxillary** (mandibular), and the **sublingual,** the latter in reality representing a group of glands. These all pour their secretions into the cavity of the mouth.

The **parotid gland** is the largest of the salivary glands. It lies just below and in front of the ear, and it varies from 15 to 30 gm. in weight. Its **superficial surface** is limited above by the root of the zygoma; behind, by the external auditory meatus, the mastoid process, and the sterno-cleido-mastoid muscle with the poste-

rior belly of the digastric; anteriorly, it extends for a varying distance over the masseter; and below, it is bounded by a line passing from the angle of the jaw backwards. The parotid gland is enclosed within the limits of this space by a sheath derived from the deep cervical fascia, which, at the anterior border of the sterno-cleido-mastoid, divides into two layers, one of which passes over, the other internal to, the gland. The two layers are united to form a thick fascial band which passes from the angle of the jaw to the sterno-cleido-mastoid, from which band the inner or deeper layer passes upwards internal to the gland to the outer surface of the styloid process. The internal layer of the fascial sheath is deficient between the internal pterygoid and the styloid process, admitting of the extension of the parotid gland to the pharyngeal wall. The internal layer of the sheath separates the gland from the internal carotid and the internal jugular. (Woolsey.)

The gland is somewhat prismatic in form, possessing three borders and surfaces and two extremities. The outer surface is covered by fascia and skin and in the lower part of its extent by platysma. Embedded in it are several superficial lymphatic glands which receive efferent vessels from the temple, cheek, eyebrows, eyelids, and from the outer aspect of the pinna. The posterior surface is in relation with the posterior belly of the digastric, the mastoid process, the styloid process,

FIG. 777.—HORIZONTAL SECTION THROUGH THE LEFT PAROTID COMPARTMENT. (Diagrammatic.) Arrow indicates the pharyngeal opening of the compartment. (Woolsey, after Testut.)



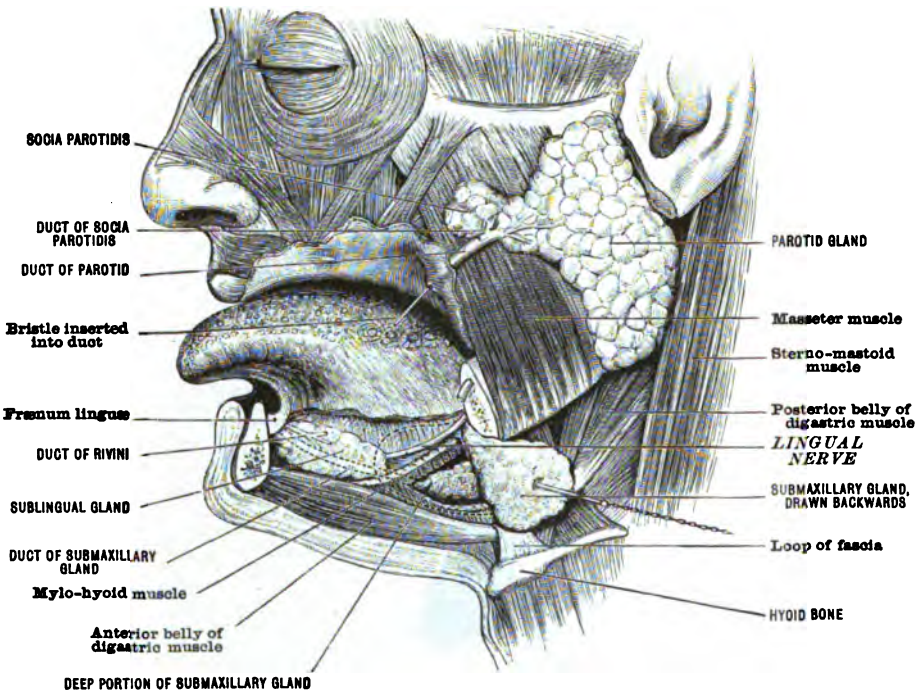
the styloid group of muscles, the posterior auricular artery, the carotid vessels, the internal jugular vein, and the ninth, tenth, and eleventh cranial nerves. The anterior surface is in contact with the posterior border of the ramus of the jaw, by which it is grooved, and with the internal pterygoid muscle. It sends forwards an irregular process, the pterygoid lobe, between the pterygoid muscles. The anterior border is irregular and thin; it extends forwards for a variable distance over the masseter; the duct and several branches of the facial nerve emerge from it, and in front of it, above the duct, there is a small separate lobe, the **accessory parotid gland.** The posterior border is in relation below with the sterno-cleido-mastoid and above with the mastoid process. The internal border is close to the wall of the pharynx. The upper extremity lies in the posterior part of the glenoid fossa of the temporal bone, behind the condyle of the jaw, and in contact with the tympanic plate; the superficial temporal artery and the temporal branch of the facial nerve emerge from its outer side. The lower extremity rests upon the stylo-maxillary ligament, which separates it from the posterior end of the submaxillary gland.

Within the substance of the gland are the following structures:—The upper part of the external carotid artery with its superficial temporal and internal maxillary branches; the commencements of the transverse facial, orbital, and middle tem-

poral branches of the superficial temporal artery, and the deep auricular branch of the internal maxillary trunk; the posterior facial (temporo-maxillary) vein, its tributaries, and its two terminal branches; the facial nerve, its cervico-facial and temporo-facial divisions crossing the posterior facial vein horizontally, and their terminal branches; the auriculo-temporal nerve, branches of the great auricular nerve, and a few deep lymphatic nodes which receive afferent vessels from the posterior part of the nasal fossa, the soft palate, and the external auditory meatus.

The **duct of the parotid** (Stenson's) issues from the anterior border of the gland, crosses the masseter a finger's breadth below the zygoma, and turns abruptly inwards round its anterior border. It penetrates the fat of the cheek and the fibres of the buccinator muscle, between which and the mucous membrane it runs for a short distance before it terminates on the summit of a little papilla, by a minute orifice. This opening is placed opposite the crown of the second upper molar tooth. The duct commences by numerous branches, which converge towards the anterior border of the gland, and receives in its passage across the masseter the duct of the accessory parotid gland. The canal is about the size of a crow-quill. Its mucous membrane

FIG. 778.—THE SALIVARY GLANDS.



is covered for a short distance, beginning with its oral termination, by stratified pavement epithelium, for the remainder of the distance by columnar epithelium. The coat of the duct is thick and tough, and consists of fibrous tissue intermixed with nonstriated muscle-fibres.

The **arteries** are derived from those lying in the gland substance and from the posterior auricular artery.

The **veins** terminate in the posterior facial (temporo-maxillary) trunk.

The nerves.—The parotid gland receives its secretory fibres from the otic ganglion, conveying impulses from the glosso-pharyngeal through the lesser petrosal; its sensory supply through branches of the fifth nerve; and its sympathetic supply from the carotid plexus. The **lymphatics** terminate in the superficial and deep cervical glands.

The parotid gland has been observed to retain its primitive condition, lying over the mandible and masseter muscle. Its lobes are absent in early childhood.

The **submaxillary gland** weighs from 7 to 10 gm., and is enclosed in a capsule of deep cervical fascia, except externally, where it is in contact with the body of the jaw. It consists of two portions, the superficial and the deep. The superficial portion is

much larger than the deep portion and is prismatic in form, possessing three surfaces and two extremities. The external surface lies in the submaxillary fossa on the inner side of the body of the jaw, and is in relation with the internal pterygoid muscle and the mylo-hyoid artery and nerve. The lower surface looks downwards and outwards; it is covered by deep fascia, platysma, superficial fascia, and skin; several superficial lymphatic glands, which receive afferent vessels from the lower part of the face, lie upon or embedded in it, and it is crossed by the facial vein and some branches of the facial nerve. The internal surface rests upon the mylo-hyoideus, hyo-glossus, and stylo-glossus, and between it and the mylo-hyoid muscle are the mylo-hyoid nerve and artery and the submental branch of the external maxillary (facial) artery. The anterior extremity is in contact with the anterior belly of the digastric; the posterior extremity is grooved by the external maxillary (facial) artery and is in relation with the stylo-mandibular ligament and the posterior belly of the digastric.

The deep portion is a mere tongue-like projection which rises from the internal surface of the superficial portion at the posterior border of the mylo-hyoid muscle. It runs forwards and upwards, in company with the duct, under cover of the mylo-hyoid and upon the hyo-glossus, stylo-glossus, and genio-glossus muscles; at its commencement the submaxillary ganglion lies just above it, and at its termination it is in close relation with the sublingual gland.

The **duct of the submaxillary gland** (Wharton's) springs from the deep surface of the superficial part of the gland; it passes forwards and inwards, along the inner surface of the deep lobe, and opens by a small orifice on the summit of a papilla by the side of the frenulum of the tongue. It is crossed superficially by the lingual nerve. It lies at first between the mylo-hyoid and hyo-glossus; next, between the mylo-hyoid and genio-glossus; and lastly, under cover of the mucous membrane of the mouth, between the genio-glossus and the sublingual gland. The duct is about 5 cm. in length, and has comparatively thin walls. It is lined by columnar epithelium.

The **arteries** to the gland are derived from the external maxillary (facial) and lingual, and they are accompanied by corresponding veins.

The nerves.—The submaxillary gland receives its secretory fibres from numerous small sympathetic ganglia situated on the submaxillary duct and in the hilus of the gland, these conveying impulses from the chorda tympani; its sensory branches probably come from the geniculate ganglion, and its sympathetic branches from the cervical sympathetic.

The **sublingual gland**—the smallest of the salivary glands—is in reality a group of glands which lie beneath the fore part of the tongue and mucous membrane of the floor of the mouth, resting deeply upon the mylo-hyoid muscle. Its position is indicated by a ridge of mucous membrane, the sublingual ridge, which runs outwards and backwards from the frenulum. It is limited externally by the sublingual fossa of the mandible, and internally by the genio-glossus, stylo-glossus, and submaxillary duct; in front it touches its fellow, and behind it approaches the deep lobe of the submaxillary gland.

The duct from the main portion of the gland, the **major sublingual duct (duct of Bartholin)**, runs alongside of the submaxillary duct, and opens either into it or on the same papilla. The several smaller glands, five to eight in number, generally grouped as forming a portion of the sublingual gland, empty each with a separate duct, the **minor sublingual ducts (ducts of Rivini)**, on the sublingual ridge.

The **arteries** are derived from the sublingual and submental, with their corresponding veins.

Nerves.—The sublingual glands receive their secretory fibres from the submaxillary and associated sympathetic ganglia, conveying impulses from the chorda tympani; sympathetic branches come from the cervical sympathetic and sensory fibres probably from the geniculate ganglion, although this question needs further investigation.

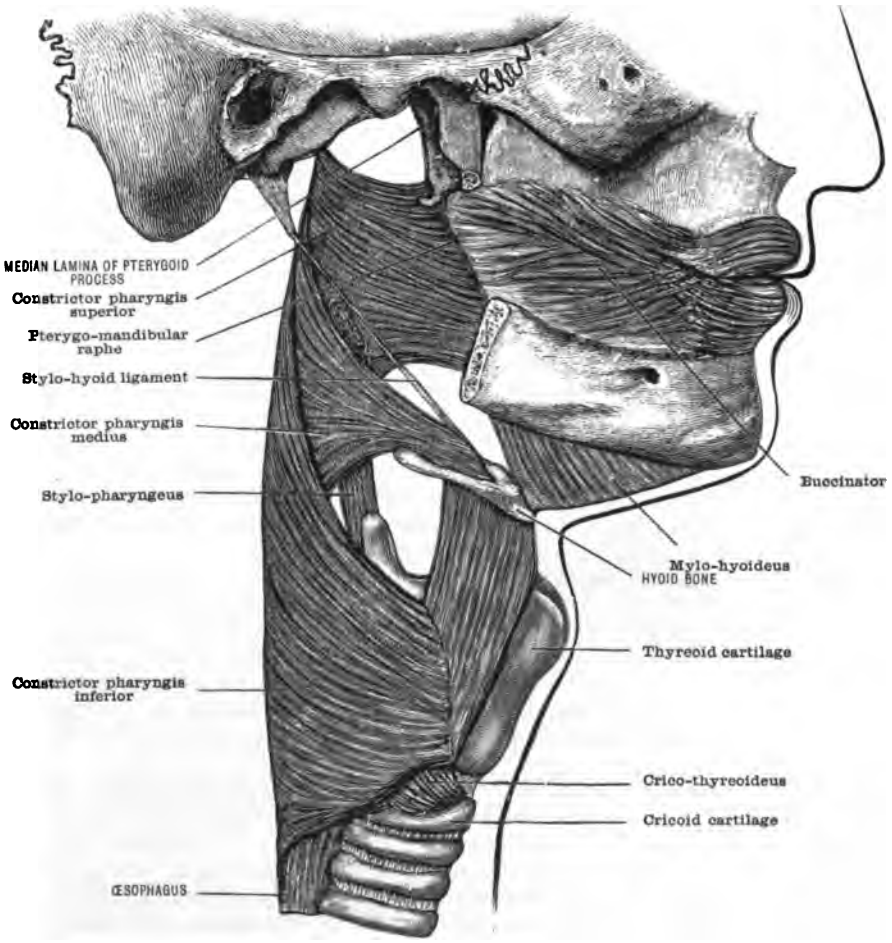
The development of the salivary glands.—The several salivary glands have their origins in buds of epithelium of ectodermal origin, which may be observed in the sixth to the eighth week of fœtal life, and which grow into the developing subepithelial connective tissue. These buds may develope as solid outgrowths of the epithelium—sublingual and associate glands—or as ridges of epithelium which become in part separated and come to lie in the connective tissue—submaxillary glands, or as furrows which become in part constricted from the epithelium, to form tubular buds—the parotid glands. These epithelial buds as they grow in length give rise to secondary outgrowths, which branch repeatedly to form the duct system and the alveoli.

THE PHARYNX

The **pharynx** is placed behind the nasal and oral cavities, and extends from the base of the skull to the lower part of the cricoid cartilage opposite the sixth cervical vertebra. The velum of the soft palate projects into it from the front, dividing it into a **nasal portion** above and an **oral portion,** including a **laryngeal portion,** below.

The openings of the two posterior nares which are in front, and the orifices of the two tubæ auditivæ or Eustachian tubes, one on each side, open into the naso-pharynx; whilst into the oral portion, below the velum, are the single openings of the mouth in front, and the larynx and œsophagus below. Thus there are seven openings leading into its cavity.

FIG. 779.—THE MUSCLES OF THE PHARYNX.



It measures from above downwards about 11·3 cm. It is flattened from before backwards, so that the cavity in this direction is extremely contracted, its mucous membrane, especially above, being thrown into numerous folds and recesses; whilst below the cavity becomes entirely obliterated, and its anterior and posterior walls, except during the act of swallowing, are in actual contact. It is widest immediately beneath the base of the skull, and narrowest below, where it passes into the œsophagus.

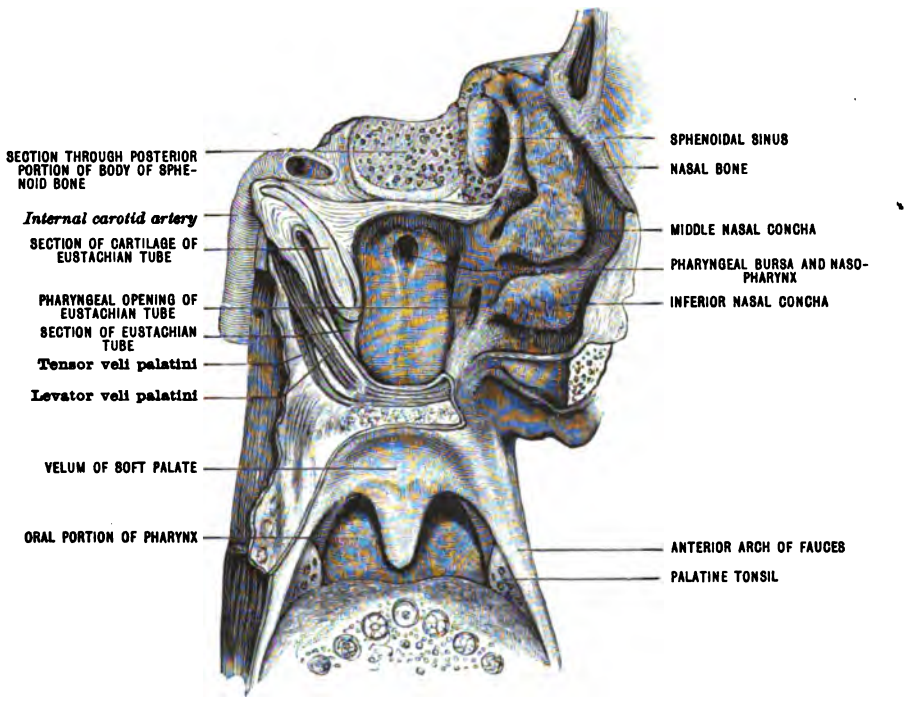
The **pharyngeal walls** are composed of a fibrous coat, the pharyngeal aponeurosis, lined by a mucous membrane, and surrounded externally by muscular layers invested by a layer of loose areolar connective tissue. This loose tissue allows of movement of the pharynx and also admits of the spreading of post-pharyngeal abscesses.

The **pharyngeal aponeurosis** is well marked above, but below it loses its density and gradually disappears as a definite structure. Above, it is attached to the basilar portion of the occipital bone in front of the pharyngeal tubercle. Its attachment may be traced outwards to the apex of the petrous portion of the temporal bone, and thence to the auditory (Eustachian) tube and median lamina of the pterygoid process. It descends along the pterygo-mandibular ligament to the posterior end of the mylo-hyoid ridge of the lower jaw, and passes thence along the side of the tongue to the stylo-hyoid ligament, the hyoid bone, and thyreoid cartilage.

The **mucous membrane** of the pharynx is continuous with the several cavities which open into it. It is closely adherent to the base of the skull, relatively thick, and dark in colour. It becomes thinner where it approaches the openings of the posterior nares and the Eustachian tubes, and below it is paler and folded longitudinally. The epithelium lining the upper, the naso-pharyngeal, portion of the pharynx is stratified ciliated columnar, but becomes stratified pavement in the lower portion.

The interior of the pharynx, viewed from behind, presents the seven openings already mentioned. On each side, beneath the pyramid of the temporal bone and be-

FIG. 780.—SECTION SHOWING THE POSTERIOR WALL OF THE PHARYNX, WITH THE PHARYNGEAL BURSA, FAUCES, ETC.



hind the auditory (Eustachian) tube, there is observed a slit-shaped lateral extension, the **pharyngeal recess** or the **recess of Rosenmüller.** In the median line, just beneath the basilar portion of the occipital bone, thus, in the uppermost portion of the posterior wall, the mucous membrane forms a small pouch with contracted orifice, the **pharyngeal bursa,** which is easily demonstrated in the fœtus and young child, but not often well marked in the adult. Embedded in the mucous membrane in the uppermost part of the pharynx, in front of the pharyngeal bursa and between the orifices of the Eustachian tubes, there is found a collection of lymph-nodules constituting the **pharyngeal tonsil.** This portion of the mucous membrane of the naso-pharynx is often swollen and chronically thickened in children. The posterior wall of the pharynx presents scattered lymph-nodules and numerous mucous glands, the so-called pharyngeal glands.

Muscles.—The **muscular coat** consists of the three pairs of **constrictor muscles,** with additional fibres derived from the stylo-pharyngeal and pharyngo-palatine (palato-pharyngeal) muscles.

The **inferior constrictor** is thick and strong. It *arises* from the thyreoid cartilage immediately behind the oblique line and superior tubercle (thyreo-pharyngeus), and from a tendinous arch extending between the inferior tubercle of the thyreoid and the cricoid cartilage and also from the lateral surface of the cricoid cartilage (crico-pharyngeus) (fig. 779). The fibres spread backwards and inwards, the lowest horizontally, whilst those above ascend more and more obliquely, and are *inserted* into the fibrous raphé of the pharynx. Some of the lowest fibres are continuous with the muscular fibres of the œsophagus, and the upper overlap the middle constrictor (fig. 779).

Near the upper border the superior laryngeal nerve and artery pierce the thyreo-hyoid membrane to reach the larynx. The inferior laryngeal nerve ascends beneath the lower border immediately behind the crico-thyreoid articulation.

The **middle constrictor** is a fan-shaped muscle which *arises* from the lesser cornu of the hyoid bone (chondro-pharyngeus), the whole length of the greater cornu, and from the stylo-hyoid ligament (cerato-pharyngeus). The diverging fibres are *inserted* into the median raphé, and blend with those of the opposite side. The lower fibres of the muscle descend, beneath the inferior constrictor, to the lower part of the pharynx; the upper overlap the superior constrictor, and reach the basilar process of the occipital bone, whilst the middle fibres run transversely (fig. 779).

The glosso-pharyngeal nerve passes downwards above its upper border, the stylo-pharyngeus is inserted between it and the superior constrictor, and near its origin it is overlapped by the hyo-glossus and crossed by the lingual artery.

The **superior constrictor** is quadrilateral in shape, pale, and thin (fig. 779). It *arises* from the lower third of the hinder edge of the median lamina of the pterygoid process and its hamular process (pterygo-pharyngeus), from the pterygo-mandibular ligament (bucco-pharyngeus), from the posterior fifth of the mylo-hyoid ridge of the mandible (mylo-pharyngeus), and from the side of the root of the tongue (glosso-pharyngeus). The fibres pass backwards to be *inserted* into the median raphé, the highest reaching the pharyngeal tubercle. The Eustachian tube and the levator veli palatini are placed above the superior arched border, and the space (*sinus of Morgagni*) between this and the basilar process, devoid of muscular fibres, is strengthened by the pharyngeal aponeurosis, this portion of it being semilunar in shape, and named the **pharyngo-basilar fascia.**

The **stylo-pharyngeus** *arises* from the base of the styloid process internally. It passes downwards and inwards to reach the pharynx between the superior and middle constrictors. Its fibres spread out as it descends beneath the mucous membrane. At the lower border of the superior constrictor some of its fibres join fibres of the pharyngo-palatinus (palato-pharyngeus), and are *inserted* into the posterior border of the thyreoid cartilage (fig. 779); the rest blend with the constrictors.

The pharyngo-palatinus (palato-pharyngeus) is described with the muscles of the soft palate.

The muscles of the pharynx are branchiomeric muscles (see p. 7), developed by segmentation from the cephalic ventral mesoderm of the third, fourth, and fifth arches, and accordingly receive their innervation from the cranial nerves distributed to these arches—the stylo-pharyngeus from the glosso-pharyngeal, and the constrictors from the glosso-pharyngeal and the pharyngeal branches of the vagus.

The development of the pharynx.—The pharynx is developed from the anterior end of the archenteron, and in part from the oral sinus. In the portion of the archenteron, with the development of the branchial arches, there are formed on each side four entodermal pouches or grooves, the branchial clefts (see p. 7). With further development the first pair of branchial clefts form the tympanic cavities and the auditory or Eustachian tubes; the lower portion of each second branchial cleft persists as a fossa in which a palatine tonsil is developed; the remains of the third and fourth pair are found on each side in the piriform sinus of the larynx. The origin of the pharyngeal tonsil may be observed in the third month of fœtal life in the form of small folds of mucous membrane which, during the sixth month, become infiltrated with diffuse adenoid tissue, lymph-nodules differentiating in this towards the end of fœtal life. The pharyngeal bursa, which is not a constant structure (Killian), may be observed as a small diverticulum of the pharyngeal wall as early as the eleventh week of fœtal life. The diverticulum develops independently of Rathke's pouch, a diverticulum from the oral sinus which gives rise to the anterior portion of the hypophysis.

THE ŒSOPHAGUS

The **œsophagus** is that portion of the alimentary tract which extends between the pharynx and the stomach. It is more constricted than the rest of the canal, being narrowest at its commencement opposite the sixth cervical vertebra and lower border of the cricoid cartilage. It is again somewhat contracted behind the left bronchus, and at its passage through the diaphragm, which is opposite the upper border of the eleventh thoracic vertebra. It has an average length of 25 cm., and in its course downwards follows the curves of the vertebral column until it finally passes forwards in front of, and slightly to the left of, the aorta to gain the œsophageal opening in the diaphragm. In addition to these curves it presents two lateral curvatures, one convex towards the left side at the root of the neck and in the upper part of the thorax, and the other concave towards the left in the lower part of the thorax where it leaves the vertebral column. It lies in the middle line at its commencement opposite the sixth cervical vertebra, and again, at a lower level, opposite the fifth thoracic vertebra.

Relations in the neck.—The œsophagus has **in front** of it the trachea, the posterior portion of the left lateral lobe of the thyreoid gland, and the left recurrent nerve, branches of the inferior thyreoid artery, and the carotid sheath. **Behind,** it rests upon the vertebral column, the longus colli muscles, and prevertebral fascia.

On its right side are placed the right carotid and right recurrent nerve; and **on the left side** the left inferior thyreoid vessels, left carotid artery, left subclavian, and the thoracic duct. The recurrent nerves pass upwards on each side to gain the interval between the trachea and œsophagus. The left nerve, as already described, lies in front of the tube, and the right along its right border.

In the thorax the œsophagus descends through the superior and the posterior mediastina. In the superior mediastinum its anterior relations are the trachea, with the deep cardiac plexus in front of its bifurcation, the left subclavian and carotid arteries crossing its left border obliquely, the left recurrent nerve, and the arch of the aorta. To the left are the left carotid and subclavian arteries, the end of the arch of the aorta, and the left pleural sac. To the right it is in relation with the right vagus nerve and the right pleural sac. Behind, it rests upon the vertebral column, the left longus colli muscle, and it overlaps the thoracic duct. As it enters the posterior mediastinum it passes behind the left bronchus and the right pulmonary artery, resting posteriorly on the vertebral column and thoracic duct. In the posterior mediastinum it has in front of it the pericardium, which separates it from the left atrium and a portion of the diaphragm; it rests upon the vertebral column, accessory hemiazygos and hemiazygos veins, the right aortic intercostal arteries, the thoracic duct, and the descending aorta. To the right is the right pleural sac, the vena azygos, which it partly overlaps, and below, the thoracic duct. To the left in the upper part is the descending thoracic aorta, and below, the left pleural sac is separated from it by a little loose areolar tissue. It is surrounded by the œsophageal plexus formed by the vagi nerves, and, as they emerge from the lower part of the plexus, the left vagus lies in front of the œsophagus and the right vagus behind.

In the abdomen the œsophagus lies in the epigastric region. In front of it is the left lobe of the liver. To the left the left lobe of the liver and the fundus of the stomach. To the right the caudate (Spigelian) lobe of the liver, and behind the decussating fibres of the crura of the diaphragm and the left inferior phrenic artery.

The **arterial** supply of the œsophagus is derived from the inferior thyreoid, the œsophageal branches of the aorta, the intercostals, the inferior phrenic, and the left gastric (gastric) arteries. The veins accompany the arteries. The **nerves** are filaments of the spinal accessory which pass to it by the vagus and the recurrent nerves.

After death the œsophagus is somewhat flattened from before backwards, but it is more rounded during life. It is closed except during the passage of food, etc.

Structure.—The wall of the œsophagus is composed of three coats—**muscular, submucous,** and **mucous.** It is surrounded with loose areolar connective tissue, connecting it with the neighbouring structures, and freely permitting its distension.

The **muscular coat** is thick, red, and consists of striped muscular fibres in about its upper third. It is made up of two distinct layers.

The **outer longitudinal fibres** commence as three flattened bands: a strong anterior arising from the ridge on the back of the cricoid cartilage (fig. 824), and two

lateral bands which blend with the fibres of the pharynx. These all unite into a continuous layer which passes below into the muscular coat of the stomach. Several accessory bands have been described, connected with the trachea, left bronchus, pericardium, and left pleura.

The **circular fibres** are continuous above with the inferior constrictor and below with the oblique fibres of the stomach; they form a uniform layer which becomes somewhat obliquely disposed towards the middle of the œsophagus.

The **submucous coat** consists of areolar connective tissue. In it are found the œsophageal glands, the ducts of which pass through the mucosa to open on the surface.

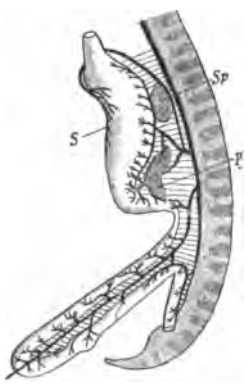
The **mucous coat** is thick and of reddish colour in the upper portion, and a greyish white in the lower portion, and deeply folded longitudinally. It presents numerous papillæ, and is limited externally by a muscularis mucosæ. It is covered by a stratified squamous epithelium.

THE PERITONEUM

The development of the peritoneum and peritoneal cavity.—There seems now little question that the cœlom, or pleuroperitoneal cavity, is folded off from the extra-embryonic cœlom at a very early stage in the development of the human embryo, this separation becoming complete with the formation of the ventral body wall and the separation from the embryo of the amnion. The peritoneal cavity is separated from the general pleuro-peritoneal cavity by the development of the septum transversum, a thick crescentic fold attached to the ventral body wall containing the omphalo-mesenteric vein and the Cuverian ducts, and continuous in the median line with the mesoderm surrounding the primitive digestive tract in the region where the entodermal outgrowth which constitutes the origin of the liver is formed. The pleuro-peritoneal cavity or cœlom is lined by a single layer of flattened mesodermal cells, known as mesothelial cells (Minot), beneath which there is found a thin layer of embryonic connective tissue. The mesothelium and the underlying embryonic connective tissue differentiate with further development into the peritoneum, the serous membrane lining the peritoneal cavity (also the pleura and pericardium).

Before a complete separation of the peritoneal cavity has taken place, at a time, therefore, when the embryonic representative of this cavity is yet in free communication with the extra-embryonic cœlom, the primitive intestine or archenteron, which is constricted off from the dorsal

FIG. 781.—DIAGRAM SHOWING THE ARRANGEMENT OF THE MESENTERY AND VISCERAL BRANCHES OF THE ABDOMINAL AORTA IN AN EMBRYO OF SIX WEEKS. (McMurrich, after Toldt.)
P, Pancreas; S, Stomach; Sp., Spleen.



portion of the yolk-vesicle, forms a relatively straight tube, to which the yolk-sac is attached. This tube is fixed to the mid-dorsal line of the body, and is covered by the peritoneum—is, therefore, outside the cavity from which the peritoneal cavity is developed. With the formation of the ventral body wall the archenteron leaves its close relation to the mid-dorsal line and moves forwards into the peritoneal cavity, pushing forwards the peritoneum. The archenteron becomes thus almost completely surrounded by the peritoneum, remaining attached to the mid-dorsal line by a layer of embryonic connective tissue, covered on both sides by mesothelium, this constituting the **mesentery.** The relatively straight tube, attached to the mid-dorsal line by the common mesentery, becomes in due course differentiated into the stomach, duodenum, small intestine, colon, and rectum, the mesentery of these respective regions being then known as the **meso-gastrium, meso-duodenum, mesentery, meso-colon,** and **meso-rectum.** The attachment of these mesenteries behind is over the aorta, from which branches pass into them to be distributed to the several regions of the intestinal canal—branches from the cœliac axis to the stomach, a branch, the superior mesenteric, to that portion of the tube which differentiates into the duodenum, small intestine, and ascending and transverse colon, and a further branch, the inferior mesenteric, to the descending colon and rectum (fig. 781).

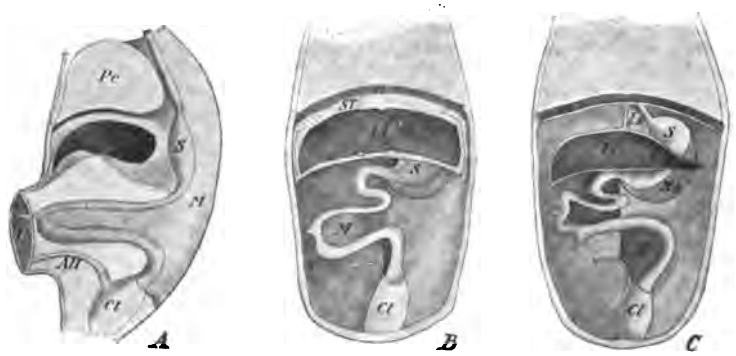
The differentiation of the mesentery is dependent on the increase in length of the intestinal canal, with its consequent folding and rotation, on the development of the liver, spleen, and pancreas, and on the fusion of the mesentery with the peritoneum, which is noted in certain regions. While the archenteron is differentiating into the intestinal canal, there is formed, from its ventral wall in the region where this is attached to the septum transversum, an entodermal bud which grows into the septum transversum and constitutes the origin of the liver. The septum transversum then becomes differentiated into two portions, an upper portion, which is thinner and encloses the Cuverian ducts, and which may be regarded as the representative of the diaphragm, and a lower, thicker portion, in which the liver developes and which extends on its caudal surface to the region of the developing umbilicus. With the further development of the liver there are developed grooves, which result in an infolding of the peritoneal covering of the septum transversum. These grooves appear at the sides and also ventral to the liver, and grow towards the median line, separating, in part, that portion of the septum transversum which contains the developing liver from the upper portion, which becomes the diaphragm. As these grooves do not meet in the median line, a portion of the septum transversum remains intact as a septum, situated in the sagittal plane, which septum may be regarded as a ventral mesentery, and forms the falciform or suspensory ligament of the liver, and a fold of peritoneum reaching from the liver to the stomach, known as the gastro-hepatic or lesser omentum. The separation of the liver and the formation and relation of these folds are shown in figs. 782, 783.

The spleen is developed within the meso-gastrium, and the pancreas, which has its origin in three entodermal buds, on its further development grows also into the meso-gastrium.

As the primitive intestine is being formed by constriction from the yolk vesicle, there is developed in it, just in front of the yolk-sac, a spindle-shaped enlargement, recognised as the origin of the stomach. This, as it elongates, loses its position in the sagittal plane, its lower end becoming directed towards the right side of the body, while its upper end, owing to the rapid

FIG. 782.—DIAGRAM (A, B): A SAGITTAL SECTION OF AN EMBRYO SHOWING THE LIVER ENCLOSED WITHIN THE SEPTUM TRANSVERSUM; (B) A FRONTAL SECTION OF THE SAME; (C) FRONTAL SECTION OF A LATER STAGE WHEN THE LIVER HAS SEPARATED FROM THE DIAPHRAGM.

All, Allantois; Cl, cloaca; D, diaphragm; Li, liver; Ls, suspensory ligament of the liver, M, mesentery; Mg, meso-gastrium; Pc, pericardium; S, stomach; ST, septum transversum; U, umbilicus. (McMurrich.)



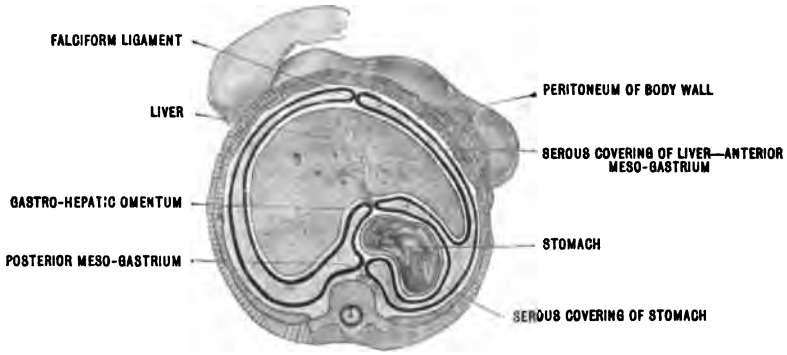
development of the liver, is pressed towards the left side. Coincident with this change in position the entire stomach rotates, so that its right surface becomes the posterior surface, while its left surface becomes the ventral surface; the posterior border thus developes into the greater curvature, and its anterior border becomes the lesser curvature. This change in the position of the stomach results in a change in the direction of its mesenteries. The gastro-hepatic or lesser omentum, which extends from the ventral border of the stomach to the liver, and is, when first developed, in the sagittal plane, with the rotation of the stomach and the consequent change of its ventral border to the lesser curvature, comes to lie in the frontal plane with its free edge directed towards the right. The meso-gastrium is also at first in the sagittal plane, but with the change in position and rotation of the stomach it elongates and becomes pushed towards the left side, extending from the greater curvature to the mid-dorsal line. With further development the meso-gastrium elongates still more and becomes the great omentum. As a result of the rotation of the stomach and the marked development of the meso-gastrium a portion of the peritoneal cavity is in part separated from the rest and comes to lie dorsal to the stomach and between the folds of the great omentum; this is known as the **lesser sac of the peritoneum**, or the **bursa epiploica**. This sac communicates with the remainder of the peritoneal cavity, or the greater sac, through the **epiploic foramen** (**foramen of Winslow**), situated dorsal to the gastro-hepatic omentum, and bounded posteriorly by the posterior body-wall and the inferior vena cava, and above by the liver.

As has been shown, the intestine is at first a relatively straight tube, attached to the mid-dorsal line by the mesentery. With the increase in length of this tube, as development proceeds, a prominent primitive loop is formed, to the summit of which the yolk-stalk is attached. As this loop increases in length it extends into the cœlom of the umbilical cord, the mesentery accompanying it. Secondary loops are formed, the mesentery becoming correspondingly folded, and the first part of the loop, from which is developed the duodenum, and the end of the loop, from which

developes the transverse colon, are brought into close proximity. On the return of the intestine from the cœlom of the umbilical cord to the peritoneal cavity, which it does during the middle of the fourth month, or, indeed, while it is still within the umbilical cord (Mall), the intestine is rotated in such a way that that portion which forms the cæcum and the ascending colon turns to the right side of the body, while the greater part of the small intestine is brought to the left side. The lower end of the duodenum is consequently carried to the left with the transverse colon lying in front of it. The mesentery for the small and the greater portion of the large intestine has now a very narrow attachment to the left of the duodenum, spreading out fan-shaped to reach the intestine (fig. 874).

FIG. 783.—PERITONEUM OF THE STOMACH AND LIVER AND OF THE ABDOMINAL WALL IN A HUMAN EMBRYO 3 CM. LONG.

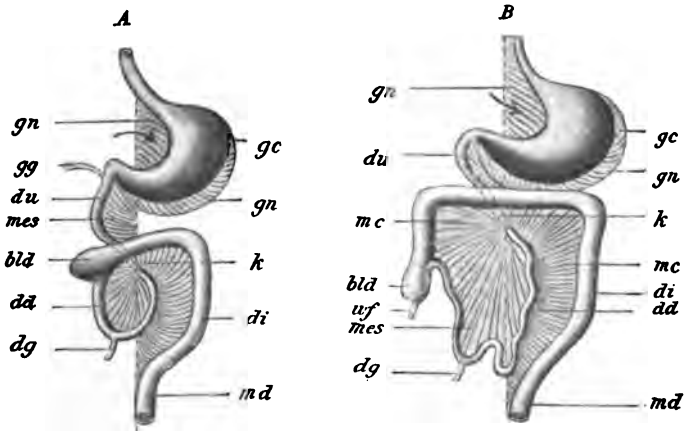
Shown in cross-section. (Kollmann.)



The mesentery retains its attachment to the mid-dorsal line for only a short time after its return to the peritoneal cavity, since soon after this period fusion of the mesentery with the peritoneum covering the posterior abdominal wall occurs in certain regions, greatly modifying the original, simple relations of the mesentery. One of the earliest of these fusions results in a change of attachment of the transverse meso-colon. The latter has, after the rotation of the intestine, a very narrow attachment just to the left of the duodenum, arching on the right side over the duodenum. With further development the transverse meso-colon fuses with the

FIG. 784.—DIAGRAMS ILLUSTRATING THE DEVELOPMENT OF THE GREAT OMENTUM AND THE TRANSVERSE MESO-COLON.

bld, Cæcum; dd, small intestine; dg, yolk-stalk; di, colon; du, duodenum; gc, greater curvature of the stomach; gg, bile-duct; gn, meso-gastrium; k, point where the loops of the intestine cross; mc, meso-colon; md, rectum; mes, mesentery; wf, vermiform appendix. (McMurrich, after Hertwig.)



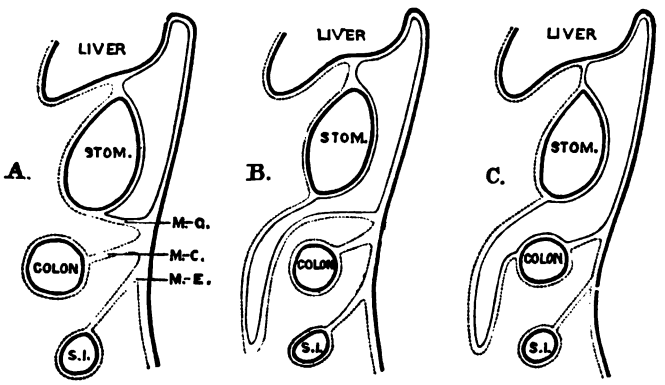
peritoneum covering the ventral surface of the duodenum and the posterior abdominal wall to the right and left of the duodenum, attaining thus an attachment which runs from right to left, across the posterior body-wall. The duodenum becomes in this way pressed against the posterior body-wall, and its mesentery, as also its posterior or dorsal peritoneal covering, fuses with the peritoneum of the posterior body-wall, the fused peritoneal surface changing into areolar connective tissue. In this way the greater portion of the duodenum comes to assume a retro-peritoneal position. The pancreas, which in its development grows between the layers of the

mesentery of the duodenum and meso-gastrium, is similarly affected, and also comes to lie outside the peritoneum. After the descending colon obtains its position on the left side of the abdominal cavity, its mesentery—the meso-colon—is brought into close relation with the posterior abdominal wall. A fusion of the two contiguous layers of the peritoneum takes place, beginning at the fifth month of fœtal life and at the median line, and extending outwards until the descending colon is reached, which thus loses its mesentery and becomes fixed to the posterior abdominal wall. A similar fusion of the mesentery of the ascending colon, as soon as this developes, takes place, resulting in a fixation of this portion of the colon to the posterior abdominal wall. In only about three-fourths of the subjects examined does the ascending and descending colon become fixed as here stated; in the remaining subjects the fixation is incomplete, and a meso-colon, of variable width, is retained. As has been shown, the meso-gastrium developes into the great omentum. The original attachment of the meso-gastrium is in the mid-dorsal line. As a result of the rotation of the stomach and the elongation of the meso-gastrium, the original left surface of the latter becomes a dorsal surface and in relation with the peritoneum of the posterior abdominal wall. A fusion of the two contiguous peritoneal surfaces then takes place, extending down to the secondary attachment of the transverse meso-colon. The meso-gastrium thus obtains an attachment which is transverse to the long axis of the body, and just above that of the transverse meso-colon. As a result of this change of attachment the upper peritoneal covering of the transverse meso-colon is brought in close relation with the lower peritoneal layer of the omentum. A fusion of the two peritoneal surfaces then takes place, resulting in an attachment of the transverse colon to the under side of the omentum, and before development is completed the two layers of the omentum also fuse. The development of the great omentum and its fusion with the transverse colon may be understood from the diagrams given in fig. 785.

The mesentery proper—that part of the original general mesentery belonging to the small intestine—also acquires secondary connections. The original attachment of this mesentery is about the origin of the superior mesenteric artery. As development proceeds, and again by fusion, it becomes 'attached posteriorly by a very short border which extends from the level

FIG. 785.—DIAGRAMS ILLUSTRATING THE FORMATION OF THE GREAT OMENTUM AND ITS FUSION WITH THE TRANSVERSE MESO-COLON AS SEEN IN VERTICAL SECTION.

M. G., Meso-gastrium; M. C., transverse meso-colon; M. E., mesentery of small intestine.



of the attachment of the transverse meso-colon to the left of the middle line, directly down to the right iliac fossa, where the ileum falls into the cæcum.' (Quain.)

In fig. 786 is shown the posterior wall of the abdomen after the removal of the intestines. together with the stomach, liver, and spleen. The lines of the various peritoneal reflexions are depicted in a diagrammatic manner. A line drawn downwards commencing at the falciform ligament of the liver, and continued past the œsophagus, through the gastro-splenic omentum, descending meso-colon, and sigmoid meso-colon represents the original attachment of the primitive median mesentery. All other lines of reflexion must be regarded as acquired or secondary.

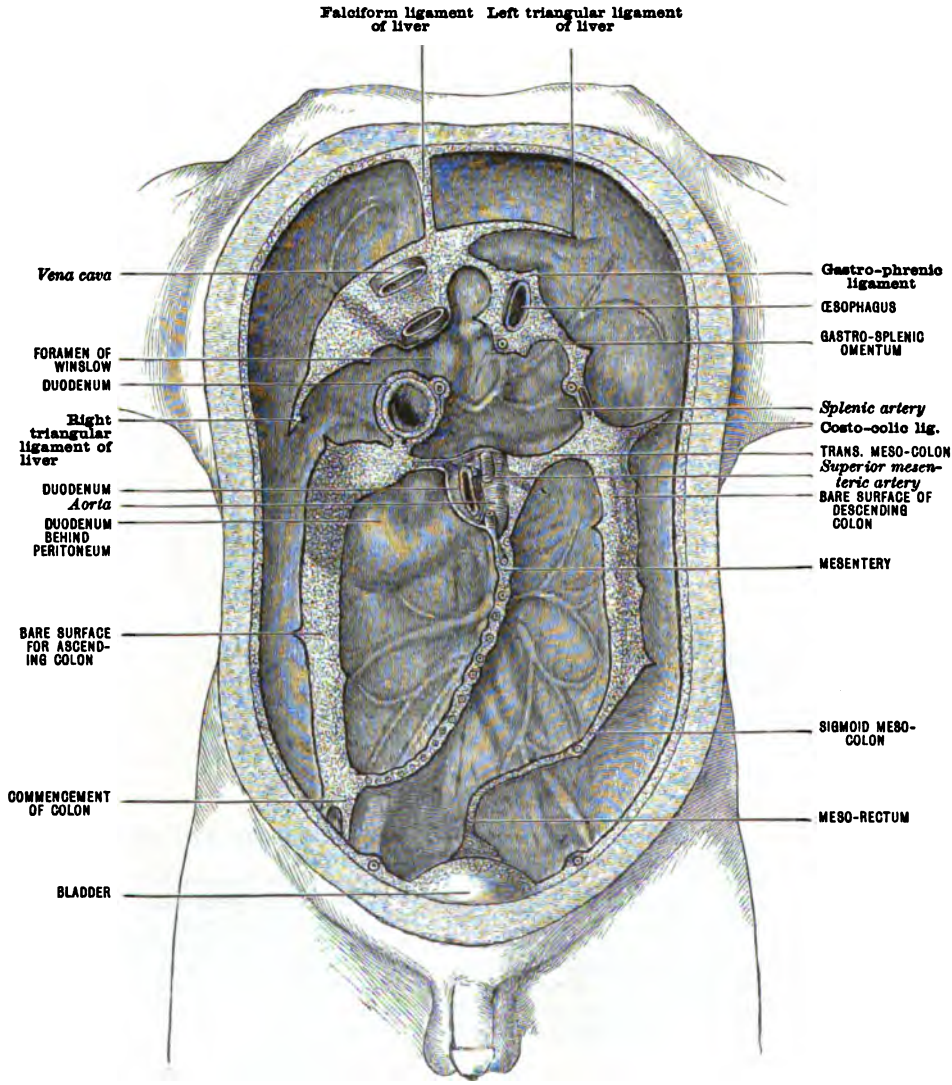
This discussion of the development of the peritoneum may now be supplemented by a more extended consideration of the peritoneum when fully developed.

The **peritoneum,** as has been shown, is a serous membrane which lines the cavity of the abdomen from the diaphragm to the pelvic floor, and invests or covers to a varying extent the viscera which that cavity contains. Viewed in its very simplest condition, it may be regarded as a closed sac, the inner surface of which is smooth, while the outer surface is rough and is attached to the tissues which surround it.

In the male subject the peritoneum forms actually a closed sac; but in the female its wall exhibits two minute punctures, which correspond to the openings of the Fallopian tubes. That part which lines the walls of the abdomen is termed the parietal peritoneum; that which is reflected on to the viscera is the visceral peritoneum. The disposition of the peritoneum may first be studied by noting its arrangement as made evident in transverse sections of the abdomen at certain levels.

The first section to be described shows the peritoneum in its simplest condition. This is a transverse section through the body, at about the level of the upper surface of the fourth lumbar vertebra, and therefore about the site of the umbilicus (fig. 787). Starting on the inner surface of the anterior abdominal wall, the peritoneum is seen to cover the transversalis fascia, and indirectly the anterior abdominal muscles; then, passing to the left, it lines the side of the abdomen, until it reaches the descending colon. This it covers, as a rule, in front and on the sides, though occasionally, as stated in considering the development of the ascending and descending meso-colon and as

FIG. 786.—DIAGRAM TO SHOW THE LINES ALONG WHICH THE PERITONEUM LEAVES THE WALL OF THE ABDOMEN TO INVEST THE VISCERA. (Cunningham.)



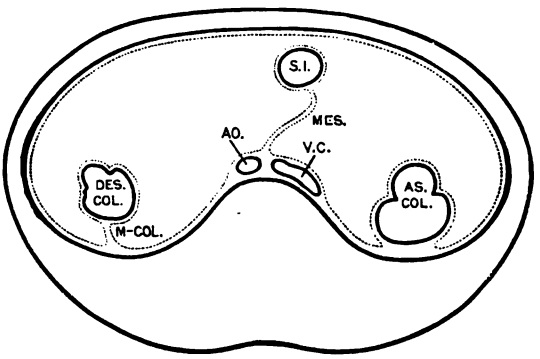
shown in the diagram (fig. 787), it forms a meso-colon. Then it passes over the bodies of the vertebræ with the large vessels upon them, and leaves the back of the abdomen to run forward to enclose the small intestine, returning again to the spine. The two layers thus form the mesentery, having between them the terminal branches of the superior mesenteric vessels. It then passes over the right half of the posterior abdominal wall, covering the ascending colon in front and at the sides only, unless there be a meso-colon, and then passes on to the side and front of the abdomen to the point from which it was first traced.

In tracing the peritoneum in a section of the body opposite the stomach (fig. 788),

on a level with the first lumbar vertebra, its course becomes more complicated and difficult to follow.

In the section already given the peritoneum as a simple closed sac can be readily conceived; but at the level now exposed the serous membrane has been so introverted that there appear to be two sacs, one leading from the other, and known respectively as the greater and the lesser sac of the peritoneum. The manner of the formation of the lesser sac is explained on page 1089, also that the two sacs communicate through the epiploic foramen (foramen of Winslow). The lesser sac or cavity is situated

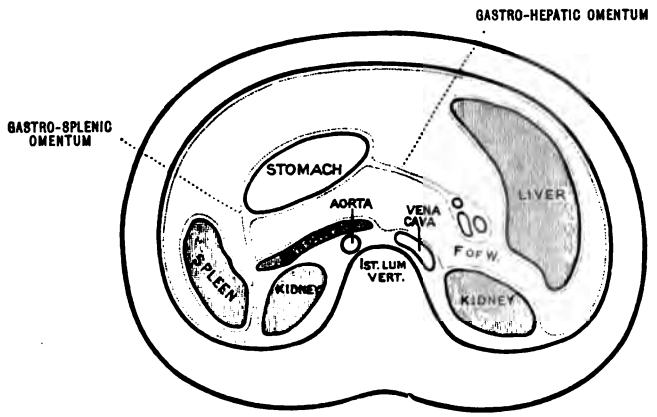
FIG. 787.—DIAGRAMMATIC TRANSVERSE SECTION OF THE PERITONEAL SAC AT ABOUT THE LEVEL OF THE UMBILICUS.



behind the stomach, so that on first opening the abdomen no trace of it is to be seen. It extends downwards between the layers of the great omentum (though, as has been stated, this part of the lesser sac is generally obliterated by adhesion in the adult). It extends upwards to the under surface of the liver, and is limited behind by the posterior abdominal wall, and below, behind the great omentum, by the transverse meso-colon. Its disposition on vertical section is shown in fig. 789.

The **epiploic foramen (foramen of Winslow)** is situated just below the liver; it looks towards the right, and will readily admit one or two fingers. It is bounded

FIG. 788.—DIAGRAMMATIC TRANSVERSE SECTION OF THE ABDOMEN AT THE LEVEL OF THE FORAMEN OF WINSLOW.

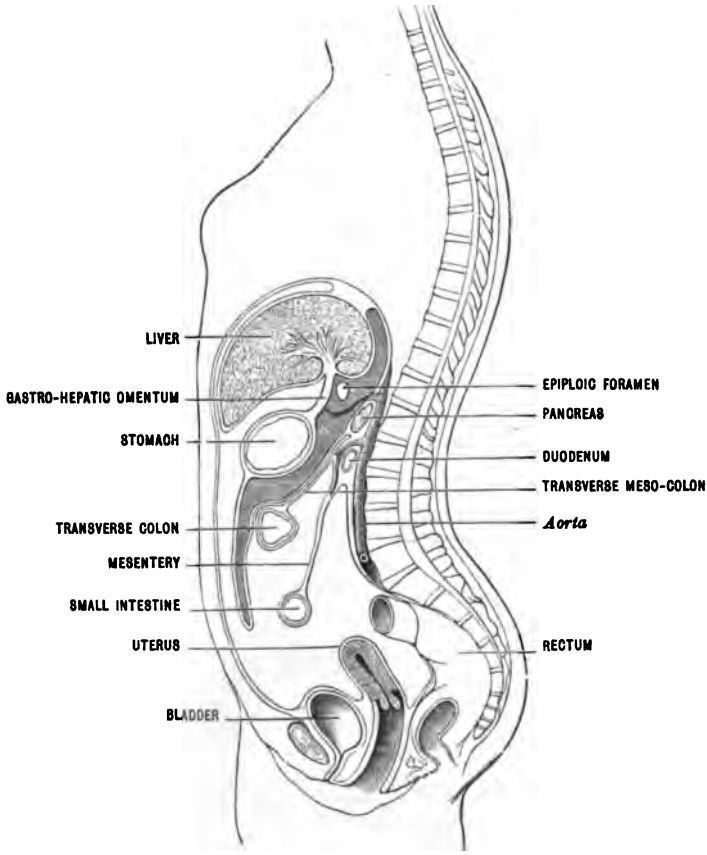


above by the caudate lobe of the liver; below, by the duodenum and hepatic vessels; behind, by the vena cava; and in front by the gastro-hepatic or lesser omentum, containing the structures passing to and from the liver. Starting at the epiploic foramen, the lesser sac will be found to turn to the left.

If, now, the peritoneum be viewed in a transverse section of the body at the level named, viz., through the first lumbar vertebra, it will be found that the section has probably passed through the epiploic foramen (fig. 788). Starting at the front of the abdomen and going to the right, the peritoneum is seen to line the

anterior abdominal wall, to pass over the side of the abdomen, and to cover the front of the right kidney; it then extends on to the vena cava, when it becomes a part of the lesser sac; then along the back of the lesser sac, over the aorta and pancreas, which separate it from the vertebral column; next it reaches the anterior of the two internal surfaces of the spleen internal to the hilus. Here it meets with another layer of peritoneum, and helps to form the gastro-splenic omentum. Leaving the spleen, it changes its direction to the right, and runs to the stomach, forming the posterior layer of the gastro-splenic omentum; it covers the posterior surface of the stomach, and leaves its upper border to form the posterior layer of the gastro-hepatic omentum, and then passes upwards and to the right to the liver. In this transverse section it is only seen passing on the right to the hepatic vessels, where it forms the posterior boundary of the epiploic foramen (foramen of Winslow). Here it bends sharply round and forms the anterior layer of the gastro-hepatic omentum; and passing

FIG. 789.—DIAGRAM TO SHOW THE PERITONEUM AS SEEN IN A VERTICAL SECTION. (Allen Thomson.)



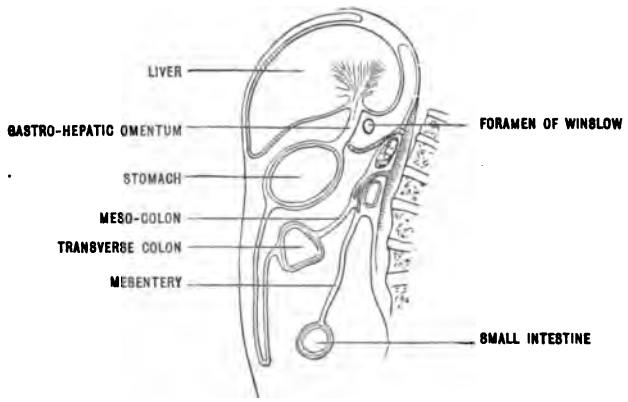
to the left reaches the stomach, which it covers in front. It then forms the anterior layer of the gastro-splenic omentum, and once more reaches the spleen. It passes right around the spleen to the back of the hilus, where it is reflected on to the left kidney (fig. 788). Hence the peritoneum passes along the side and front of the abdomen to the point from which it started. In this section the liver is so divided as to appear separated from all connection with the other viscera and the abdominal wall, and to be surrounded by peritoneum.

The course of the peritoneum in a **longitudinal section of the body** will now be considered (fig. 789). Starting at the umbilicus and passing downwards, the peritoneum is seen to line the anterior abdominal wall. Before reaching the pelvis it covers also the urachus, the deep epigastric arteries, and obliterated hypogastric arteries, which can be seen to form ridges beneath it. For some little way above

the os pubis the peritoneum is loosely connected with the abdominal wall, a circumstance which is made use of in supra-pubic cystotomy. Moreover, as the distended bladder rises from the pelvis it can detach the serous membrane to some extent from the anterior abdominal wall. In extreme distension of the bladder the peritoneum may be lifted up for some 5 cm. vertically above the symphysis. On reaching the os pubis it is reflected on to the upper part of the bladder, covering it as far back as the base of the trigone; thence it is reflected on to the rectum, which it covers in front and at the sides on its upper part, or forms for such part a distinct meso-rectum. Between the bladder and rectum it forms the **recto-vesical pouch.** The mouth of this pouch is bounded on either side by a crescentic fold, the plica semilunaris. In the female the peritoneum is reflected from the bladder on to the uterus, which it covers; it then extends so far down in the pelvis as to pass over the upper part of the vagina behind; thence it extends to the rectum. The peritoneum which invests the uterus is reflected laterally to form the broad ligaments. The fold between the vagina and rectum forms the **recto-vaginal pouch,** or pouch of Douglas. The membrane has now been traced back to the spine.

Following it upwards, the sigmoid flexure will be found to be completely covered by peritoneum, a meso-colon attaching the gut to the abdominal wall. As seen in fig. 787, the ascending and descending colon in either loin are covered by peritoneum, as a rule, in front and on the outer sides. A little higher up in the median line the peritoneum passes forwards, to enclose the small intestine, and,

FIG. 790.—DIAGRAM TO SHOW THE PERITONEUM AS SEEN IN VERTICAL SECTION. (Allen Thomson.)

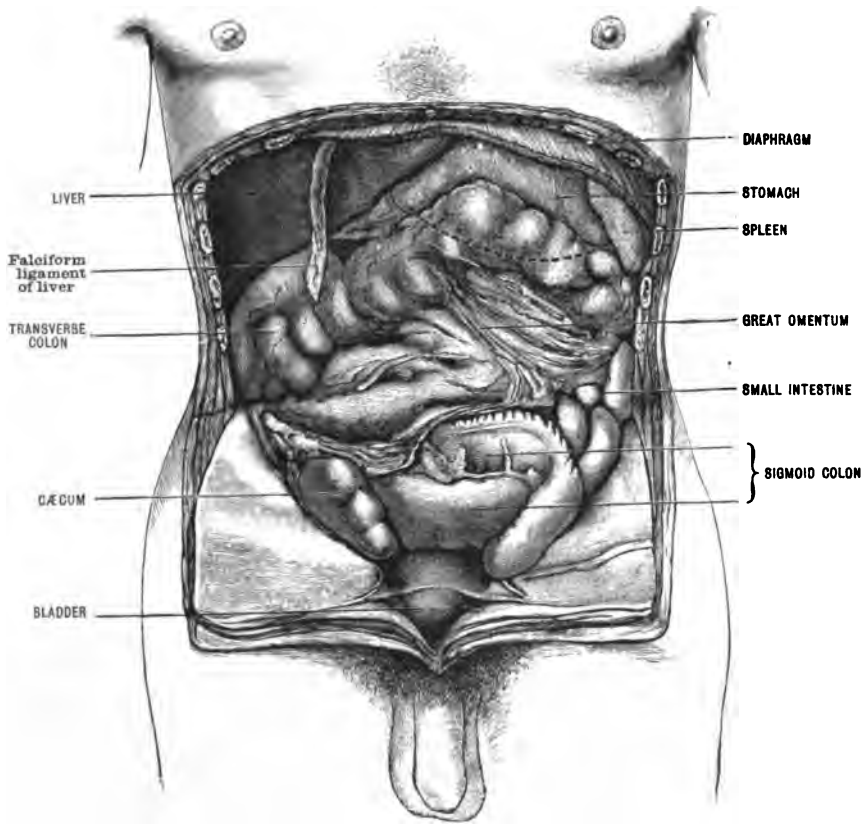


returning to the spine, forms the mesentery (fig. 789). It now passes over the third part of the duodenum to the pancreas, from which point it again passes forwards to form the lower layer of the transverse meso-colon. It invests the transverse colon below and partly in front, and then leaves it to pass downwards to take part in the great omentum. Running downwards some distance, it returns and forms the anterior layer of the omentum. On reaching the stomach it goes over the anterior surface, and at the upper border forms the anterior layer of the lesser or gastro-hepatic omentum, which extends between the stomach and the liver. It invests the inferior surface of the liver in front of the transverse fissure, and, turning over its anterior border, covers the upper surface. At the posterior limit of the upper surface it leaves the liver and goes to the diaphragm, forming the superior layer of the coronary ligament. It covers the anterior part of the dome of the diaphragm, and, once more reaching the anterior abdominal wall, can be followed to the umbilicus, where it was first described. On reference to the diagram (fig. 789) the student might be led to suppose that the two sacs as above described are quite separate. This, of course, is not the case; but in a longitudinal section of the body made anywhere to the left of the epiploic foramen (foramen of Winslow), it is impossible to show the direct connection between the two sacs.

The peritoneum has only been traced in this longitudinal section so far as it concerns the greater sac. It now remains to follow upon the same section such part of the membrane as forms the **lesser sac.** The peritoneum here will be seen

to cover the posterior surface of the stomach; and from thence it runs upwards to the liver, forming the posterior layer of the lesser or gastro-hepatic omentum. It reaches the liver behind the transverse fissure. It covers only a part of its posterior surface, and is reflected on to the diaphragm, forming the lower layer of the coronary ligament. It now goes downwards over the hinder part of the dome of the diaphragm to the spine, separated from the latter by the great vessels. On reaching the pancreas it passes forwards, and forms the upper layer of the transverse meso-colon. It then covers the upper half of the transverse colon, and, descending, forms the innermost layer of the great omentum. It now ascends, and, arriving at the greater curvature of the stomach, passes on to its posterior wall. At this point its description was commenced. From fig. 788 it will also be evident that the peritoneum forming the lesser sac comes into contact with the spleen, forms one layer of the gastro-splenic omentum, and is in relation with the upper part of the left kidney.

FIG. 791.—THE VISCERA AS SEEN ON FULLY OPENING THE ABDOMEN WITHOUT DISARRANGEMENT OF THE INTERNAL PARTS. (After Sarazin.)



The precise manner in which certain organs—such as the liver, the cæcum, the duodenum, and the kidneys—are invested by peritoneum is described in the accounts of those viscera. To such accounts the reader is referred for a description of the many 'ligaments' (such as those of the bladder and liver) which are formed by the peritoneum.

The great omentum.—As is evident from its development, the great omentum is formed of four layers of peritoneum, though this is quite impossible to demonstrate in an adult, the individual layers having become adherent.

The great omentum acts as an apron, protecting the intestines and providing them with a heat-economising covering of fat. It is nearly quadrilateral in shape, and is variable in extent. In fig. 790 the great omentum is shown to be connected with the greater curvature of the stomach, on the one hand, and the transverse

colon, on the other. This is the arrangement described in the text. Under certain conditions (as shown in fig. 789) the posterior layer of the great omentum returns to the posterior abdominal wall, and is independent of the transverse meso-colon. This variation is readily understood if the development of the great omentum and meso-colon is borne in mind.

Mr. Lockwood has made some investigations on the lengths of the transverse meso-colon and great omentum in thirty-three cases. In twenty, under the age of forty-five, only one subject had a great omentum long enough to be drawn beyond the pubic spine; in five, the omentum reached as far as the pubes. In the cases beyond forty-five years it was the exception rather than the rule to find an omentum which could not be pulled beyond the lower limits of the abdomen.

The **lesser** or **gastro-hepatic omentum** consists of a double layer of peritoneum extending between the lesser curvature of the stomach and the transverse fissure of the liver. If the two anterior layers of the great omentum are traced upwards, they are seen to enclose the stomach, and then join together again at the lesser curvature to form the lesser or gastro-hepatic omentum (fig. 789). It is connected above with the portal (transverse) fissure and the fissure for the ductus venosus; below, with the upper curvature of the stomach; the left extremity encloses the œsophagus; the right border contains the hepatic vessels and is free, forming the anterior boundary of the epiploic foramen.

The **gastro-splenic ligament** or **omentum** connects the left extremity of the stomach with the spleen, continuing the layers of peritoneum which enclose the stomach.

The gastro-phrenic and phreno-colic ligaments.—As the peritoneum passes from the diaphragm to the stomach it forms a small fold just to the left of the œsophagus. This is the gastro-phrenic ligament. A strong fold of the membrane also extends from the diaphragm (opposite the tenth and eleventh ribs) to the splenic flexure of the colon, and is known as the phreno-colic or costo-colic ligament.

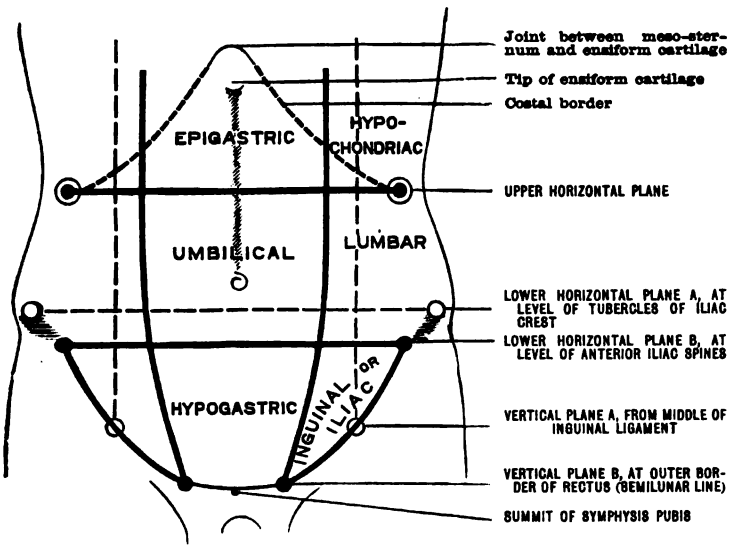
THE ABDOMEN

The **abdomen** properly consists of that part of the body cavity situated between the diaphragm and the pelvis. It is bounded above by the diaphragm; below, by the brim of the true pelvis; behind, by the vertebral column, diaphragm, quadratus lumborum and psoas muscles, and by the posterior portions of the ilia. At the sides it is limited by the anterior parts of the ilia and the hinder segments of the muscles which compose the anterior abdominal wall, viz., the transversus, internal oblique, and external oblique. In front, besides these muscles, there are the two recti and pyramidales muscles. External to the peritoneum the abdomen is lined by a special layer of fascia. It is customary for anatomists and physicians to divide, for purposes of description, the ventral surface of the abdomen, by means of two horizontal and two vertical lines, into nine regions. A complete uniformity in the use of the boundary lines marking these regional subdivisions has not as yet been attained, although the variations in the schemes used are not marked as concerns the main features. It should be borne in mind that it is necessary that the boundary lines used should be converted into planes carried through the whole depth of the abdomen and defined on the dorsal as well as the ventral surface, and that the relations defined can only be approximate, owing to the wide range of the physiological variation in the position of the abdominal contents. The nine regions or subdivisions may be outlined as follows:—The upper horizontal line or plane passes through the lowest point of the tenth costal cartilages, about 5 cm. above the umbilicus, and dorsally through the second lumbar vertebra. The lower horizontal line and plane passes through the level of the anterior superior iliac spines, and dorsally about 2·5 cm. below the promontory of the sacrum. (Cunningham has recently proposed that this line be passed through the tuberculum cristæ, therefore in a plane slightly higher than the interspinous plane.) For the longitudinal lines and planes it has been customary to run vertical lines parallel with the mid-body line or mid-sagittal plane, and from the

middle of the inguinal ligaments. The outer border of each rectus would seem, however, preferable as a guide for these longitudinal lines and planes, which may be easily localised above by the lateral infra-costal furrow and below by the pubic spines, leaving thus on each side an inguinal region which includes the whole of the inguinal canal. The boundary lines here indicated may be made intelligible by a reference to fig. 792. The regions thus outlined are known as the right and left hypochondriac and epigastric regions, found above the upper horizontal line; the right and left lumbar and the umbilical regions, found between the two horizontal lines; the right and left inguinal or iliac and the hypogastric regions, found below the lower horizontal lines.

On freely laying open an abdomen from the front, the general form of the space is seen to be an irregular hexagon, the sides of which are formed as follows:—The upper two by the margins of the costal cartilages with the ensiform cartilage between; the two lateral sides by the edges of the lateral boundary; and the two lower by the two inguinal ligaments which meet at the pubes.

FIG. 792.—DIAGRAM OF THE ABDOMINAL REGIONS.



In this irregular hexagon the following organs can be observed without disarranging their normal position (fig. 791). Above, on the right side, under the costal cartilages, can be seen the liver, which extends from the right across the median line to a point below the left costal cartilages. Below the liver, and lying to the left side, can be seen the anterior surface of the stomach; from the lower border of the stomach the omentum extends downwards, and shining through it can be seen the middle part of the transverse colon. On each side and below the irregularly folded omentum are exposed the coils of the small intestine; in the right iliac fossa a part of the cæcum appears; and in the left iliac fossa a coil of the sigmoid flexure is usually evident.

To the left of the stomach and under cover of the lower ribs of the left side the edge of the spleen may possibly be observed; and just below the edge of the liver, and about the level of the tip of the ninth rib, the gall-bladder may be seen. The dome of the urinary bladder may be noticed just behind the symphysis pubis and in the median line. The disposition of the viscera in the fœtus is shown in fig. 810.

THE STOMACH

General description.—The **stomach** is situated in the upper part of the abdominal cavity and to the left side. When empty, it is found in the left hypochondrium and left half of the epigastric region. Above it are the liver and diaphragm, while below is the transverse colon. It is somewhat pyriform in outline, with the small end of the figure twisted upwards. Its length is about 30 cm., and its width 10 to 12·5 cm. The distance between its two orifices varies from 7·5 to 15 cm. Its average capacity is two to three litres. It weighs 135 gm.

There are two orifices, two borders, and two surfaces to be noticed. The left, the splenic or cardiac end of the viscus, is much expanded and forms the **fundus.** At the right or pyloric end there is another slighter expansion, called the **pyloric antrum** (fig. 793).

The **cardiac orifice,** by which the œsophagus opens into the stomach, is situated about 7·5 cm. from the left extremity, owing to the bulging to the left of the fundus. The **pyloric orifice,** or **pylorus,** is situated to the extreme right, and is more anterior in position than the cardiac orifice.

The **pylorus** is produced by a thickening of the visceral walls of the stomach at the junction of that organ with the duodenum. The circular muscular fibres which surround the stomach are here thickened into a strong ring, thus forming a sphincter which can be felt from the outside. The longitudinal fibres pass over the circular fibres, and are not generally supposed to take part in the thickening. The mucous membrane is pushed in by the muscular ring and also thickened. The pyloric opening represents the narrowest part of the digestive canal, measuring in fullest diameter only about 13 mm. There is no special sphincter at the cardiac end of the stomach, the œsophagus passing directly into its walls, and becoming wider as it does so.

The two **borders** are situated above and below, and run between the two orifices. The upper is known as the **lesser curvature,** and is about 7·5 to 12·5 cm. long. It is concave along its whole length, except near the pylorus, where it takes part in the pyloric antrum (fig. 794). The lower border is called the **greater curvature,** and is convex except near the right extremity, just before the formation of the pyloric antrum, where there is a slight depression. It is about four times as long as the upper border.

The two **surfaces** lie between the two borders. They are of equal extent, and are named the anterior and posterior surfaces.

Relations to surrounding parts.—The degree of obliquity of the stomach in its relation to the long axis of the body has been a disputed point, the majority of authorities holding that it lies slightly obliquely from left to right; while a few (Luschka and Lesshaft) maintain that its direction is vertical. In an early period of development the organ is vertical, and in some rare instances this position may be maintained throughout life. As a rule, however, the organ is placed obliquely, and lies in the left hypochondriac and epigastric regions (figs. 810, 814, and 815). Its position, under normal conditions, must be liable to much variation.

The *cardiac end,* or fundus, reaches as high as the level of the sixth chondro-sternal articulation, being a little above and behind the heart apex. The cardiac orifice is at the level of the seventh left costal cartilage, at a point about 2·5 cm. from the sternum. Behind, it is about on the level with the body of the tenth or eleventh dorsal vertebra. The *pylorus* is on a lower level and nearer the surface than the cardiac end, and is opposite a point to the right of the middle line, 7·5 to 10 cm. below the sterno-xiphoid articulation, on the level of a line drawn between the tips of the ninth costal cartilages (fig. 814). Behind, it is on a level with the twelfth thoracic or first lumbar spine (fig. 815). Its position is much influenced by the state of distension of the stomach.

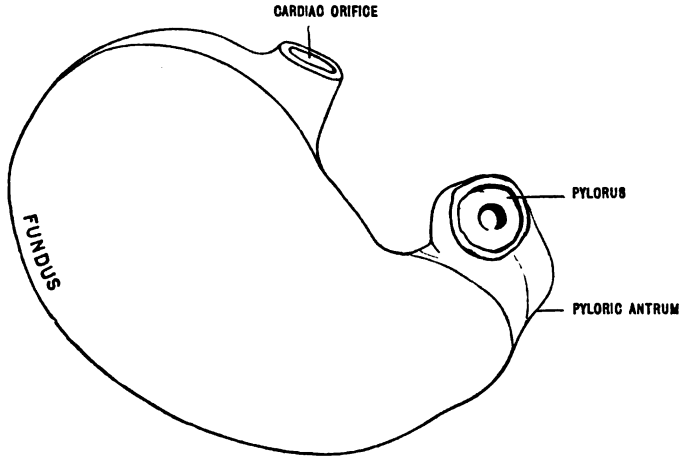
The *posterior surface* of the stomach looks backwards and downwards, lying on the transverse meso-colon, spleen, splenic artery, pancreas, left kidney and suprarenal capsule, and great abdominal vessels (fig. 818).

The *anterior surface* looks upwards and forwards. Its relations are of importance in connection with the operation of gastrostomy. A certain portion of this surface comes into immediate contact with the abdominal wall; this portion is triangular in shape, is bounded on the right by the edge of the liver, and on the

left by the cartilages of the eighth and ninth ribs; and below by a horizontal line passing between the tips of the tenth costal cartilages (fig. 814). Besides the abdominal wall, this surface is covered by the diaphragm and the under surface of the left lobe of the liver (fig. 814).

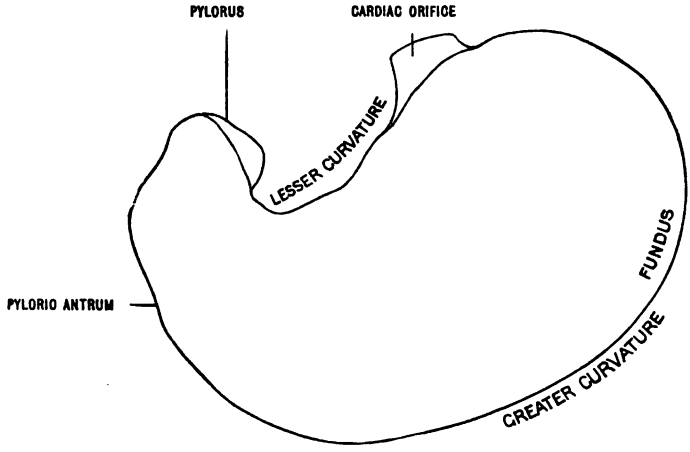
Relations to the peritoneum.—The stomach is covered by peritoneum in its whole extent, except immediately along the curvatures and upon a small triangular space at the back of the cardiac orifice, where the viscus lies in direct contact with

FIG. 793.—POSTERIOR SURFACE OF THE STOMACH.



the diaphragm and possibly with the upper part of the left suprarenal capsule. It is enclosed between two layers. These two layers at its upper border or lesser curvature come together to form the gastro-hepatic (lesser) omentum, and at the lower border or greater curvature extend downwards to form the great omentum (figs. 788, 789). At the left of the œsophagus the two layers pass to the diaphragm, forming the gastro-phrenic ligament; and at the fundus they pass on to the spleen, forming the gastro-splenic ligament.

FIG. 794.—ANTERIOR SURFACE OF THE STOMACH

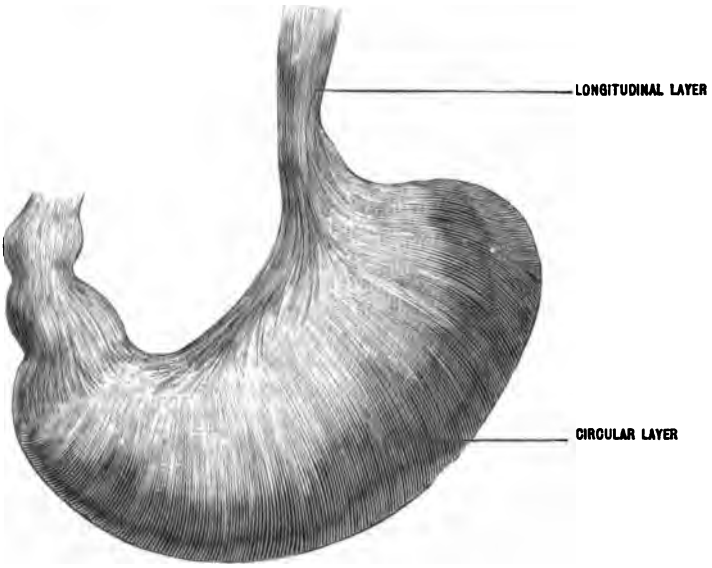


Alteration of position.—When the stomach is empty, the surfaces are flat and the pyloric end is situated nearer the median plane than the costal margin, and under cover of the liver. As it distends, it occupies the left dome of the diaphragm and tilts up the heart apex. Moreover, it undergoes some alteration in position. The greater curvature is elevated and carried forwards, the anterior surface is directed upwards and the posterior downwards, and the pylorus passes some distance

to the right. The pyloric orifice, which in the empty stomach looks to the right, is so turned as to look backwards. This rotation about its long axis is influenced by the fixity of the lesser curvature of the organ.

Structure.—The walls of the stomach consist of four coats—serous, muscular, submucous, and mucous.

FIG. 795.—MUSCULAR COAT OF THE STOMACH. (Luschka.)

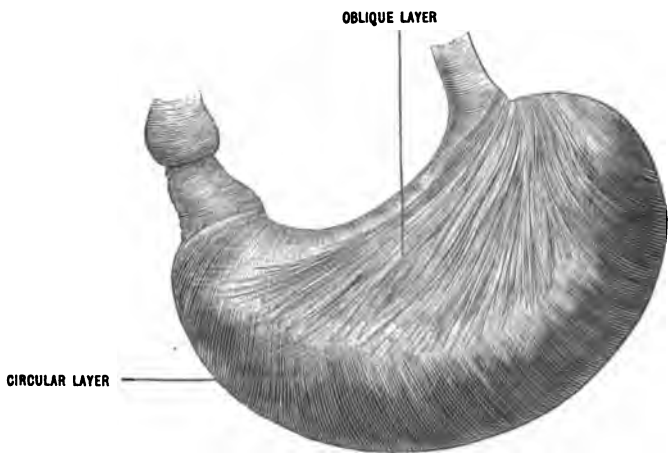


The *external serous coat* is formed by the peritoneum, and has to the naked eye the usual shiny appearance of that membrane.

The *muscular coat* consists of three layers:—

A *longitudinal layer* externally, which is continued from similar fibres on the œsophagus, and is thickest along the curvatures, more particularly the lesser. At the pylorus the fibres are more regularly placed around that orifice (fig. 795).

FIG. 796.—MUSCULAR COAT OF THE STOMACH. (Luschka.)



A *circular layer*, which regularly surrounds the whole stomach and becomes much thicker at the pyloric end, where it forms the sphincter. These circular fibres, which are in part replaced on the fundus by fibres belonging to the next layer, are arranged perpendicularly to the long axis of the stomach (fig. 796).

An *oblique layer*, continuous with the deep circular fibres of the œsophagus.

They first encircle the fundus and then pass to the left of the œsophagus towards the great curvature. They unite finally with the circular fibres on the body of the stomach (fig. 796).

The *submucous coat* is made up of areolar tissue, in which the blood-vessels break up.

The *mucous* or *internal coat* is pink in colour and soft to the touch, and when the stomach is not distended, has a rugose appearance. It is covered with simple columnar epithelium, and with a lens shows the openings of numerous glands. A thin layer of muscular tissue—the *muscularis mucosæ*—bounds the mucous membrane externally. The mucous membrane is thickest in the pyloric area and thinnest over the fundus. In the mucosa of the stomach are found the gastric, peptic, and pyloric glands, and numerous lymph-nodules known as lenticular glands.

Nerves.—The nerves of the stomach are the right and left vagus, the right nerve passing over the posterior surface and the left over the anterior. The organ is also connected with the sympathetic system by means of the cœliac (solar) plexus.

Blood-supply.—The stomach receives its blood-supply from many branches. From the cœliac axis there is the left gastric (gastric) artery, which runs along the lesser curve from left to right, anastomosing with the right gastric (pyloric) branch of the hepatic. Along the greater curve run the right and left gastro-epiploic arteries, anastomosing at the middle of the border, the left being a branch of the splenic, the right a branch of the hepatic, through the gastro-duodenal artery. The stomach also receives branches from the splenic (vasa brevia) at the fundus.

The blood of the stomach is returned into the portal vein. The coronary vein and pyloric vein open separately into the portal vein; the right gastro-epiploic vein opens into the superior mesenteric, the left into the splenic.

Lymphatics.—There is a set of nodes lying along the lesser and the pyloric portion of the greater curvature, and others at the pyloric and cardiac ends. These are entered by lymphatic vessels which, beginning in the mucous membrane, accompany all the gastric veins, but chiefly those of the lesser curvature. Vessels also accompany the left gastro-epiploic veins to terminate in the splenic nodes. On its way to the receptaculum chyli, the gastric lymph passes through groups of nodes situated above and behind the head and neck of the pancreas.

THE INTESTINES

THE SMALL INTESTINE

The **small intestine** is that part of the intestinal canal which lies between the pylorus and the ileo-cæcal valve. It is conveniently divided into three portions:—the **duodenum, jejunum,** and **ileum.** It is of the average length in the adult male (between the ages of twenty and fifty) of 8 metres. In the female it is slightly shorter. The length is independent, in the adult at least, of age, height, or weight. The length may vary in the male from 11·5 to 7·5 m.; in the female, from 9 to 6·3 m.

With the exception of the duodenum, the small intestine lies for the most part inside the more fixed portions of the large intestine (figs. 791, 803). It is also, with the exception of the duodenum, connected to the posterior abdominal wall by a process of peritoneum, the *mesentery*. This broad membrane is seen to extend from above downwards, and from left to right from the duodenum above to the ileo-cæcal valve below, enclosing the jejunum and ileum along the whole of their extent (figs. 786, 787, 789).

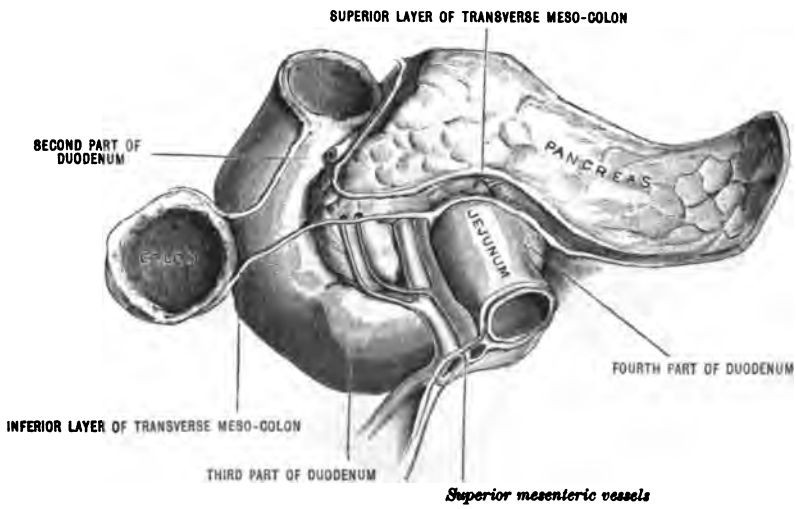
The **duodenum**—the first portion of the small intestine—is, unlike the other parts of that bowel, very definite in position and extent. It is that part which is not contained by the mesentery. It is formed from the first bend of the small intestine. This is at first so large that it appears as a part of the stomach, but as it receives the ducts of the liver and pancreas, it must be regarded as the embryonic representative of the duodenum; its position behind the transverse colon is due to the rotation from left to right of the intestine in the fœtus. It is the most fixed as

well as the widest part of the small intestine. It measures 3·7 to 5 cm. in diameter, and is about 25 cm. long. It has been compared in general shape to a horseshoe, though not very aptly, as the one side is so much longer than the other. It is arranged in a curved manner around the pancreas, and readily lends itself to a division into four parts (fig. 797).

The *first part*—the *superior*, or *ascending*—is hardly 5 cm. long. Beginning at the pylorus, and passing upwards and backwards to the right, it ends at the neck of the gall-bladder. It is the most movable of the four portions. It is covered by the two layers of peritoneum which are continued from the stomach, and by these it is completely surrounded in front, but is covered behind only in the vicinity of the pylorus. Above it are found the liver (quadrate lobe) and gall-bladder. The gut itself forms the lower boundary of the epiploic foramen (foramen of Winslow). Below it is the pancreas; and behind are the common bile-duct, hepatic vessels, and portal vein.

The *second part*,—the *descending portion*,—not quite 7·5 cm. long, extends from the neck of the gall-bladder to the third lumbar vertebra, a short bend marking the separation between the first and second parts. This part is covered by peritoneum in front only, the membrane being derived from a continuation of the layers of the transverse meso-colon (fig. 797).

FIG. 797.—THE DUODENUM FROM IN FRONT.



It is more fixed than the first portion. It is in relation in front with the transverse colon and meso-colon. On its left side is the pancreas (fig. 808), and the common bile-duct a little more posteriorly. The loop formed by the pancreatico-duodenal arteries runs also along the left margin of this part of the bowel.

Behind lie the right kidney and the renal vessels and vena cava.

Some of the muscular fibres of this part of the duodenum are said to be continuous with the lobules of the pancreas. Into this segment of the bowel, at its inner and back part and some 10 cm. from the pylorus, the common bile-duct and pancreatic duct enter (figs. 798, 808, and 819).

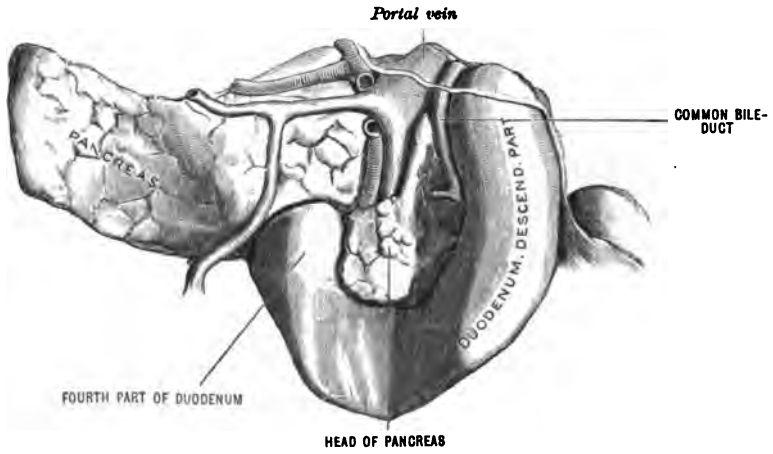
The *third part*, or *transverse portion*, is the longest, being about 10 cm. long. It extends from the body of the third lumbar vertebra on the right side, and passes obliquely across the spine to the upper part of the left side, ascending a little on its way. In front of the third part of the duodenum is found the lower layer of the transverse meso-colon. The superior mesenteric vessels cross this part of the bowel, running between it and the pancreas to reach the mesentery (fig. 797). Along the upper border runs the inferior pancreatico-duodenal artery. The gut is in relation above with the pancreas and superior mesenteric artery. Behind are the vena cava, aorta, and crura of the diaphragm (figs. 798, 808). It is the most fixed portion of the duodenum, and is covered in front only by peritoneum.

The *fourth part* of the duodenum, or *second ascending* portion, ascends vertically

on the left side of the spine. This vertical portion—which is covered entirely in front and partly at the sides by peritoneum—is at least 2·5 cm. in length (figs. 797, 798, and 799). The end of the duodenum is very firmly fixed in its place by the *suspensorius duodeni*. This name has been given to a fibro-muscular band that contains, according to Treitz, non-striated muscular fibres, and descends to the vertical part of the duodenum from the lumbar part of the diaphragm, passing to the left of the cœliac artery and behind the pancreas. Lockwood points out that this band is continued on, after being inserted into the duodenum, between the layers of the mesentery. He suggests the name of the 'suspensory muscle of the duodenum and mesentery,' and says, 'together with the other constituents of the root of the mesentery, it forms a band of considerable strength, sufficient not only to support the weight of the intestines and mesentery, but also to resist the pressure of the descent of the diaphragm.'

In connection with this fourth portion of the duodenum, mention may be made of certain peritoneal folds and fossæ which are of some surgical interest by reason of their being associated with retro-peritoneal hernia. Three such fossæ may receive mention, namely, the superior and inferior duodenal fossæ and the paraduodenal fossa. On drawing the terminal portions of the duodenum to the right, two triangular folds of peritoneum, the superior and inferior duodenal folds, which extend from the wall of the duodenum to the posterior abdominal wall, may be observed. Each fold has a free edge. Beneath each fold is found a pouch of peritoneum, con-

FIG. 798.—THE DUODENUM FROM BEHIND.



stituting the **superior** and **inferior duodenal fossæ.** The former, the smaller, opens downwards and is present in about 50 per cent., while the latter opens upwards and is present in about 75 per cent., of the subjects examined. (Jonnesco.) The **paraduodenal fossa** (fossa of Landzert) is not often found in the adult; when present, it is situated to the left of the last part of the duodenum, and is formed by a fold of peritoneum enclosing the inferior mesenteric vein.

Jejunum and ileum.—The position of the several parts of the small intestine is considered in discussing its development, and may be ascertained by a study of figs. 802, 803, and 804.

The **jejunum** (*jejunus*, empty) is the name given to the upper two-fifths of the small intestine below the duodenum.

The term **ileum** (εἰλεῖν, to twist) is applied to the last three-fifths of the bowel. The ileum ends at the ileo-cæcal valve. The coils formed by the jejunum and ileum are very movable, are completely invested by peritoneum, and are supported and attached to the posterior parietes by the mesentery.

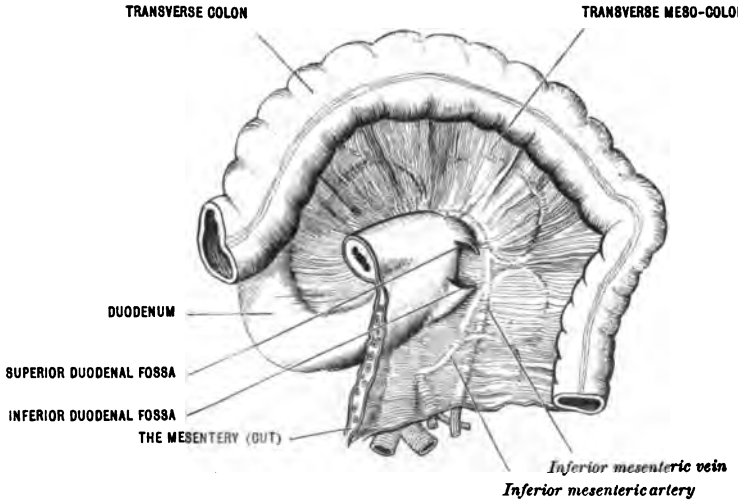
The intestine alters gradually in character from above downwards. If a segment from the middle of the jejunum be compared with a portion of the middle ileum, the following differences would be noted. The diameter of the jejunum is about 3·7 cm., that of the ileum 3·1 cm.; the jejunum has thicker walls, is more vascular, and is provided with a more complex mucous membrane.

Meckel's diverticulum.—From 30 to 90 cm. from the end of the ileum is sometimes seen a diverticulum, or blind tube or cord, coming off from the free margin of the bowel. This is Meckel's diverticulum, and represents the remains of the yolk-stalk.

The mesentery.—The mesentery extends from the end of the duodenum to the ileo-cæcal junction. It envelopes and supports the ileum and jejunum. Its upper or right layer is continuous with the under layer of the transverse meso-colon and with the peritoneum that invests the ascending colon. Its lower or left layer joins with the serous membrane that encloses the descending colon and that forms the sigmoid mesentery (fig. 799).

The point at which the mesentery is attached above is on a level with the lower border of the pancreas and just to the left of the vertebral bodies. From this point the insertion of the mesentery follows an oblique line that runs downwards and to the right, crossing the great vessels, and ending in some part of the iliac fossa (fig. 786). In the absence of an ascending meso-colon (the normal condition) the peritoneum that covers the cæcum is reflected from the hinder surface of that part of the bowel on to the posterior abdominal wall; at this reflexion the mesentery ends. If an ascending meso-colon exists, the mesentery terminates by joining it. The parietal attachment of the mesentery measures, as a rule, about 15 cm. (fig. 786). The width of the mesentery from the spine to the intestine varies in different parts of the canal; its average width may be taken as between 20 and 22·5 cm. It soon

FIG. 799.—DUODENAL FOSSÆ AND FOLDS. THE PARADUODENAL FOSSA IS NOT SHOWN. (Cunningham.)



attains its full width, and within 30 cm. of the end of the duodenum is already 15 cm. broad.

The ordinary type of mesentery conforms to the shape of half a circle, but the membrane is liable to considerable variation. It is not uncommon to find the mesentery maintaining a considerable width up nearly to the end of the ileum.

Structure of the small intestine.—Its coats are four in number—viz., serous, muscular, submucous, and mucous. The intestine receives its *serous* covering from the peritoneum, and, with the exception of certain parts of the duodenum which have been described, it is covered entirely by it, save only where the layers leave it behind to form the mesentery. The line of attachment of the mesentery marks the attached border of the small intestine.

The *muscular coat* is divided into an external longitudinal layer and an internal circular, the circular being the thicker of the two. Both layers are uniform around the bowel, and become thinner as the cæcum is approached.

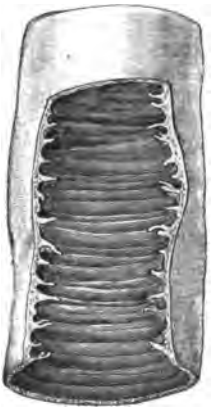
The *submucous coat* consists of areolar tissue connecting the muscular and mucous tunics. A thin layer of muscular tissue, known as the muscularis mucosæ, separates the mucous membrane from the submucous coat.

The *mucous coat*, thicker at the upper than at the lower part, is lined throughout with simple columnar epithelium having a striated, cuticular border. The

surface of the mucosa is covered with minute processes called *villi;* these give the membrane a finely flocculent appearance, which has been compared to the pile of velvet. They are largest and most numerous in the duodenum and jejunum, in which regions they are leaf-shaped, and become gradually more separated, smaller, and of conical shape in the ileum. Between the bases of the villi are found the openings of short, simple tubular glands—the crypts of Lieberkühn. Beside the villi are certain large folds or valvular flaps: these are the plicæ circulares (*valvulæ conniventes*). They are permanent crescentic folds of mucous membrane and submucosa set transversely to the long axis of the intestine. The majority extend from one-half to two-thirds of the distance around the lumen (fig. 800). The largest are more than 5 cm. long, and about 8 mm. wide. Some of the plicæ circulares form complete circles and others spirals. These mucous folds do not exist at the beginning of the duodenum; they are very large just below the entrance of the bile-duct, and remain conspicuous until the middle of the jejunum is reached, and then become smaller, and gradually disappear at the lower part of the ileum.

Scattered over the whole of the mucous membrane of the small intestine are numerous small lymph-nodules, the larger of which extend into the submucosa; these are the so-called *solitary glands.* Aggregations of lymph-nodules, known as Peyer's patches or agminated lymph-nodules, situated in the mucosa and submucosa, are found in the lower ileum. They are oval, from 1·2 to 7·5 cm. in length and about 2·5 cm. in breadth, and are placed in the long axis of the bowel along a line most remote from the mesentery.

FIG. 800.—PORTION OF THE SMALL INTESTINE, LAID OPEN TO SHOW THE PLICÆ CIRCULARES. (Brinton.)



A number of closely set tubulo-alveolar glands, which extend into the submucosa and are known as duodenal or *Brunner's glands,* may be exposed by dissection in the submucous coat of the first part of the duodenum.

Blood-supply of the small intestine.—The small intestine receives its blood from the superior mesenteric artery and a branch coming indirectly from the hepatic, the superior pancreaticoduodenal. The superior mesenteric artery runs between the layers of the mesentery and gives off six or seven relatively large branches and a variable number of smaller branches. The first two or three of the larger branches divide into an ascending and a descending branch, which join above and below with the corresponding branches of the contiguous arteries, forming thus a single row of arches. From about the beginning of the second quarter of the small intestine a second tier of arches, formed in a similar manner, is often noted, and below the middle of the jejuno-ileum more than two tiers of arches may be present the complexity of the arches increasing, while the size of the vessels diminishes. From the convex border of the most distally placed arches there pass to the intestine straight branches, so-called vasa recta. Near the beginning of the jejunum these are numerous and large, and have a length of about 4 cm., and are quite regular. After the first third of the intestine is passed the vasa recta become smaller and shorter, and towards the lower end of the ileum they become short and irregular and are often less than 1 cm. in length. (Dwight.) The blood is returned by means of the superior mesenteric vein, which, with the splenic vein, forms the portal (fig. 495).

The **lymphatics** form a continuous series, which is divided into two sets—viz., that of the mucous membrane and that of the muscular coat. The lymph-vessels of both sets form a copious plexus and end in the mesenteric lacteals.

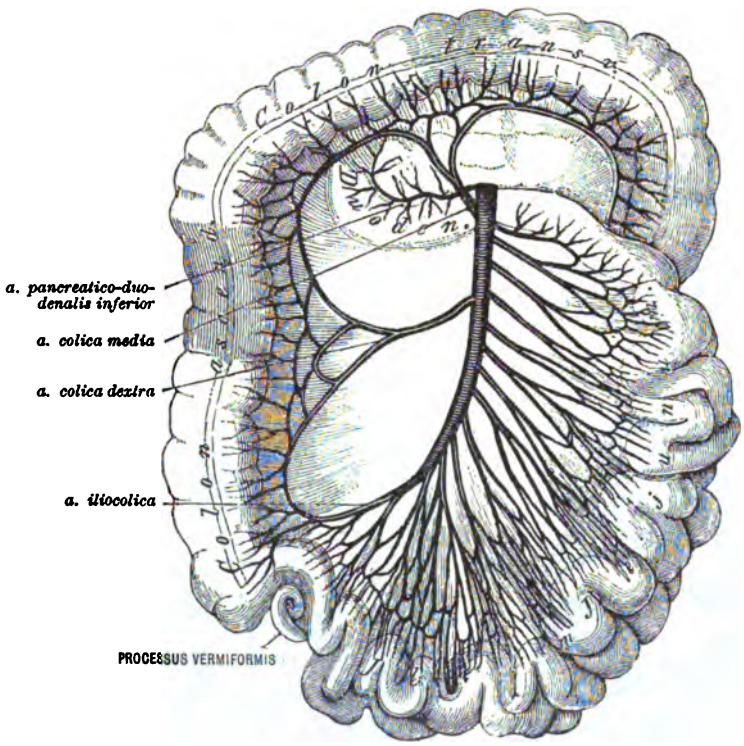
The nerves.—The small intestine is supplied by means of the superior mesenteric plexus

which is continuous with the lower part of the cœliac (solar) plexus. The branches follow the blood-vessels, and finally form two plexuses: one (Auerbach's) which lies between the muscular coats; and another (Meissner's) in the submucous coat.

Development of the small intestine.—As the intestine is being separated from the yolk-vesicle it forms at first a relatively straight tube, and as the tube elongates there is formed a single primary loop, situated in the sagittal plane of the embryo, which loop extends into the cœlom of the umbilical cord; to its summit is attached the constricted attachment of the yolk-vesicle, the yolk-stalk. This primary loop of the intestine, as it elongates, turns on an axis, so that its caudal portion turns towards the left and its cephalic portion towards the right. We may then speak of a right and a left half of the loop. Near the top of the left half of the loop there is noted an enlargement which marks the cæcum, the greater part of the left half of the loop forming, therefore, the large intestine, while the right half of the loop forms the small intestine. In the further growth of the loop the right half elongates more rapidly than the left half, so that the cæcum is no longer found in the middle of the loop. In an embryo of the fifth week, as noted by Mall, whose account is here followed closely, 'the right half of the loop has a number of small bends in it, which are of great importance in the further development of the intestine.' These small bends or loops he has marked with the numbers 1, 2, 3, 4, 5, 6. The first of these bends is primarily

FIG. 801.—VESSELS OF THE SMALL INTESTINE.

The small intestine has been laid over to the left and the transverse colon turned upwards. (Gegenbauer.)



not clear, appearing as a portion of the pyloric end of the stomach; however, it is recognised by the fact that the ducts of the liver and pancreas terminate in it, marking it as the duodenum. The omphalo-mesenteric veins and arteries, the future superior mesenteric vessels, pass through the middle of the mesentery of the large primary loop and pass over the sixth bend or secondary loop, to which is also attached the yolk-stalk. With the elongation of the intestine these six bends or loops become accentuated and acquire secondary loops or coils, nearly all of which are still found in the cœlom of the umbilical cord, but even with this more complicated coiling of the intestine the six primary divisions may be clearly made out. (See fig. 802.)

The large intestine, the left half of the large primary loop, lies in the sagittal plane of the embryo and does not grow as rapidly as the small intestine, and while this is acquiring the secondary coils, the whole mass rotates about the large intestine as an axis. 'By this process the small intestine is gradually turned from the right to the left side of the body, and in so doing is rolled under the superior mesenteric artery. This takes place while the large intestine has an antero-posterior direction and before there is a transverse colon.' (Mall.) With the return of the small intestine from the umbilical cœlom to the peritoneal cavity, which occurs apparently quite suddenly and during the middle of the fourth month, the cæcum comes to lie in the right half of the abdominal cavity, just below the liver; the greater portion of the remainder of the large intestine then lies transversely across the abdominal cavity as the transverse colon. The six groups of loops of the small intestine, recognised in younger stages, may still be recognised,

the loops of the upper part of the small intestine having rolled to the left of the superior mesenteric artery, while the loops which were formerly in the cord are found in the right side of the abdominal cavity. It is not difficult to trace these six groups of loops through the later stages of

FIG. 802.—MODEL OF STOMACH AND INTESTINE OF HUMAN EMBRYO 19 MM. LONG. The figures on the intestine indicate the primary coils (× 16). (Mall.)

fœtal life to the newly born, and thence to the adult stage. In the adult, as also through the various stages of development, loop 1 forms the duodenum. From the primary groups of coils marked 2 and 3 are developed the greater part of the jejunum, arranged in two distinct groups

FIG. 803.—MODEL SHOWING COURSE OF INTESTINE, MADE FROM THE SAME CADAVER FROM WHICH FIG. 804 WAS DRAWN. (Mall.)

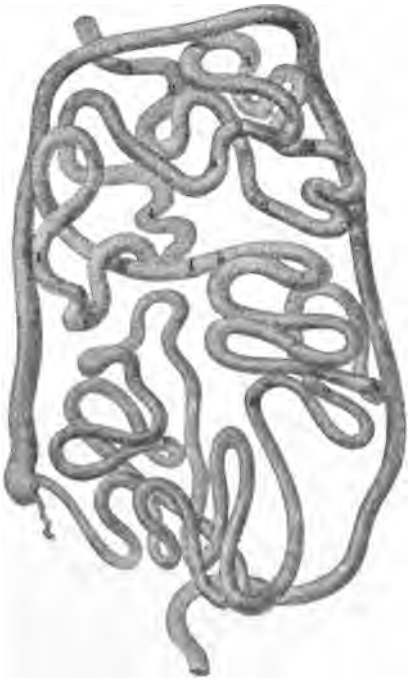
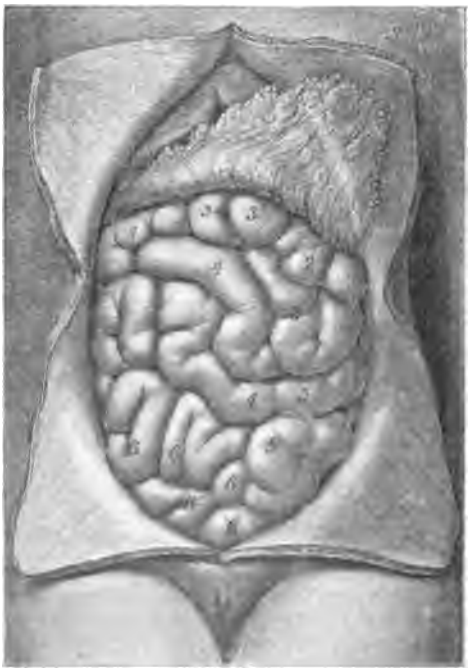


FIG. 804.—THE USUAL POSITION OF THE INTESTINE IN THE ABDOMINAL CAVITY.

The numbers in the figure mark the parts which are homologous with the primary bends and groups of coils numbered from 1 to 6. (Mall.)



of loops, situated in the left hypochondriac region. The part of the intestine developed from group 4 of the primary coils passes across the umbilical region to the right upper part of the abdomen. That part developed from group 5 of the primary coils recrosses the median line to

the left iliac fossa, while that part derived from group 6 of the primary coils is found in the false pelvis and the lower part of the abdominal cavity between the psoas muscles. (Mall.) Figs. 803 and 804 may serve to make clear these statements. They present what may be regarded as the normal arrangement of the small intestine, having been found 21 times in 41 cadavers examined. Variations from this arrangement occur; the great majority of such variations are, however, not of sufficient importance to require special mention.

THE LARGE INTESTINE

The **large intestine** is that part of the alimentary canal which extends between the ileum and the anus. It is divided into the following parts:—Cæcum, ascending, transverse, descending, and sigmoid colon, and rectum. It is so arranged as to surround the small intestine, making a circuit around the abdominal cavity from right to left (fig. 791). The *cæcum* lies in the right iliac fossa; thence the colon passes vertically upwards on the right side (*ascending colon*) until the liver is reached. Here it forms a more or less rectangular bend (the right colic or hepatic flexure), and then passes transversely across the belly (*transverse colon*) below the stomach. It then reaches the spleen, where it makes a second sharp bend (the left colic or splenic flexure), and, passing vertically downwards on the left side (*descending colon*), reaches the left iliac fossa. At this point it forms the loop of the sigmoid colon, and finally passes through the pelvis as the rectum (fig. 809). It is much larger in diameter than the small intestine, and has not the same general convoluted arrangement. Leaving out of consideration the dilated portion of the rectum, it is wider at the beginning than at the end. It varies in width at different parts from 6·2 to 3·1 cm. The length from the root of the appendix or tip of the cæcum to the point where the meso-rectum ends is, in the male, about 1·4 m., and in the female about 1·3 m. The extremes found in a number of cases were, for both sexes respectively, 1·9 m. and 0·97 m.

The large intestine, in all parts except the rectum, has a peculiar arrangement of its walls, which gives it a very different appearance from the small intestine. It is *sacculated*, and the sacculation is produced by the gut having to adapt its length to three shorter muscular bands which run the course of the intestine. These bands, which are about 12 mm. wide and 1 mm. thick, are really the longitudinal fibres of the muscular wall, which are chiefly collected along three lines (fig. 807). One band is situated *posteriorly* on the attached border, another runs *anteriorly*, and the third is situated on the *inner* side of the ascending and descending colon, and on the lower border of the transverse colon. All these bands start at the vermiform appendix and are lost on the rectum. The mucosa presents numerous transversely placed semilunar folds, which involve also the submucosa. Along the whole length of the large intestine, except the lower part of the rectum, are certain small appendages (*appendices epiploicæ*), seen mostly along the line of the inner muscular band. They are pouches of peritoneum containing fat.

The cæcum or caput coli.—The cæcum is a *cul-de-sac* forming the first part of the large intestine. It is defined as that part of the colon which is situated below the entrance of the ileum. Its breadth is about 7·5 cm., and its length about 6·2 cm. It appears very early in the development of the intestinal canal, even before the primary loop, which extends into the cœlom of the umbilical cord, is formed. During further development the primary thickening which marks the cæcum increases in size, forming a conical projection in the region where the large intestine joins the small intestine.

It lies in the right iliac fossa, and is usually situated upon the psoas muscle, and so placed that its apex or lowest point is just projecting beyond the inner border of that muscle (figs. 791, 808). It is entirely enveloped in peritoneum, and is free in the abdominal cavity. The apex of the cæcum usually corresponds with a point a little to the inner side of the middle of the inguinal ligament. Less frequently the cæcum will be found to be in relation with the iliacus muscle only; or the bulk of it will lie upon that muscle, while the apex rests upon the psoas. In a number of cases the cæcum is entirely clear of both psoas and iliacus muscles, and hangs over the pelvic brim, or is lodged entirely within the pelvic cavity. Some part of the cæcum may pass even to the left of the median line of the body.

This part of the colon is liable to considerable variation.

Its *variations* may be described under *four types:*—

1. The fœtal type is conical in shape, the appendix arising from the apex. This

process is a continuation of the long axis of the colon. The three muscular bands which meet at the appendix are nearly at equal distances apart (fig. 805, A).

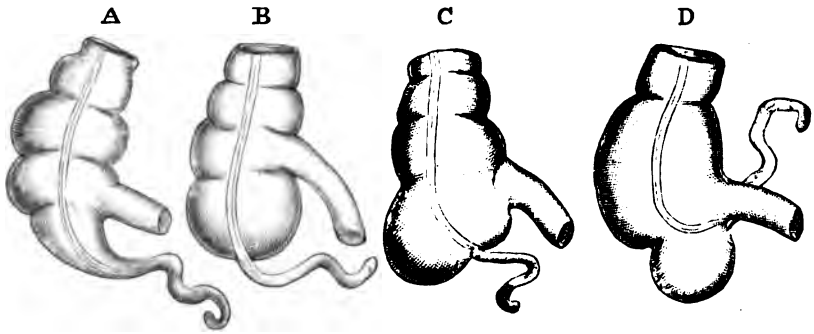
2. The second form is more quadrilateral in shape than the last; the three bands retain their relative positions; the appendix appears between two bulging sacculi, instead of at the summit of a cone (fig. 805, B).

3. In the third type, that part of the cæcum that lies to the right side of the anterior band grows out of proportion to that part to the left of the band. The anterior wall becomes more developed than the posterior, so that the apex is turned so much to the left and posteriorly that it nearly meets the ileo-cæcal junction. A false apex is formed by the highly developed part to the right of the anterior band. This is the usual cæcum found (fig. 805, C).

4. In the fourth type, the development of the part to the right of the anterior band is excessive, while the segment to the left of the band has atrophied. In this form the anterior band runs to the inferior angle of junction of the ileum with the cæcum. The root of the appendix is posterior to that angle. There is no trace of the original apex, and the appendix appears to spring almost from the ileo-cæcal junction (fig. 805, D.)

Other Variations.—The cæcum may vary in its general development. It is sometimes small and insignificant; in other cases it reaches a large size. It may be so rotated that the ileum passes behind the colon and opens on the right side. The posterior part has been seen much more developed than the anterior, so that the ileum has entered from the front, and the appendix has come off from the anterior wall. The cæcum may remain undescended, and be found just under the liver or in the vicinity of the umbilicus. The cæcum and colon may be suspended by a mesentery common to the whole intestinal canal. In such cases the primitive condition of the peritoneal fold which supports the small and large intestine is permanently retained.

FIG. 805.—THE FOUR TYPES OF CÆCUM. (Treves.)



The vermiform appendix.—Attached to what is really the original apex of the cæcum is a narrow, blind tube: this is the vermiform appendix. It usually comes off about 2·5 cm. below the ileo-cæcal valve on the inner and posterior side of the bowel, though occasionally it forms the true apex of the cæcum. In the adult the average length is 10 cm., the extremes being 2·5 and 15 cm. In the majority of instances the appendix is much twisted upon itself. Its usual position is behind the end of the ileum and its mesentery, and pointing in the direction of the spleen. It may occasionally ascend vertically behind the cæcum.

The vermiform appendix has no true mesentery, as may readily be understood when its development is considered. The appendix usually presents, however, a falciform fold of peritoneum derived from the left layer of the mesentery of the ileum. Its origin from this layer is along a straight line which is situated at a short distance from the intestine, and which is not quite parallel with the margin of the bowel. In general outline this fold of peritoneum is triangular. In the adult it does not extend along the whole length of the tube. It is, in fact, too short for the appendix, and it is this that accounts for the twisted condition of this process. Along the free margin of the fold runs a branch of the ileo-colic artery.

At an early stage in the development of the intestinal canal, when this presents a single primary loop and soon after this loop has turned on its axis, there is observed on the left half of the loop, near its top, an enlargement which marks the beginning of the large intestine. With further growth this enlargement developes a lateral outgrowth on the side opposite to that to which the mesentery is attached, therefore free from the mesentery, a conical projection of the

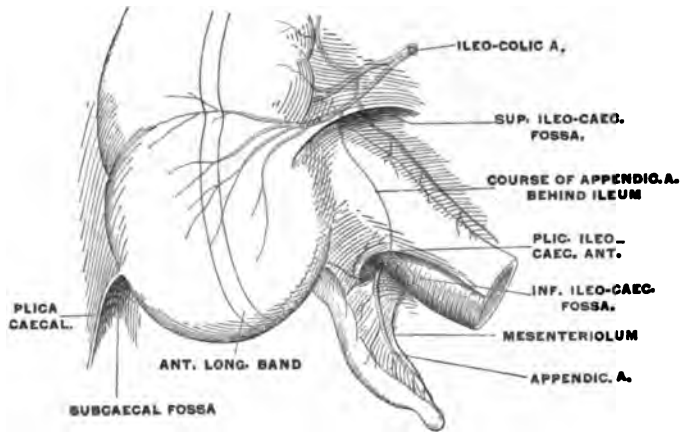
large intestine or colon beyond the place where this is joined to the small intestine being thus formed. This conical projection or pouch of the large intestine, which continues the colon somewhat beyond the insertion of the small intestine, developes into the cæcum and the vermiform appendix. It does not present, in its further growth, a uniform enlargement. The portion nearest the colon grows in size more rapidly than the terminal portion, this difference in size becoming more apparent as development proceeds, the smaller terminal portion forming the vermiform appendix. On the return of the intestine to the peritoneal cavity the cæcum lies on the right side, immediately below the liver, a position which it retains during the later fœtal months and to about the fourth month after birth, and during this time the sigmoid colon is relatively long and flexed. After about the fourth month after birth the sigmoid colon becomes straighter and relatively shorter, and the cæcum becomes gradually pushed downwards into the right iliac fossa, and there is thus established an ascending colon. (Treves.) The cæcum may, however, even in the adult, retain its embryonic position on the right side immediately beneath the liver.

Ileo-cæcal fossæ.—About the cæcum, and especially in the vicinity of the ileo-cæcal junction, are certain fossæ collectively known as the ileo-cæcal fossæ. Two only appear to be fairly constant, although a third is now and then present. The first, the *superior ileo-cæcal fossa*, is formed by the passage across the junction of the cæcum and ileum of the anterior cæcal artery, a branch of the ileo-colic artery, which produces a fold of peritoneum limiting a pouch. It is on the anterior aspect of the bowel, and the pouch opens downwards.

The second fossa is not quite so simple. If the cæcum be turned upwards so as to expose its posterior surface as it lies *in situ*, and if the appendix be drawn down

FIG. 806.—CÆCUM, APPENDIX, AND END OF ILEUM, WITH THE BLOOD-SUPPLY AND THE NEIGHBOURING FOSSÆ.

Somewhat schematic. (Woolsey, after Merkel.)



so as to put its mesentery on the stretch, a peculiar fold will be found to join that mesentery. This fold arises from the border of the ileum which is most remote from the insertion of its mesentery. It then passes over the ileo-cæcal junction on its inferior aspect, is adherent to the cæcum, and finally joins the surface of the mesentery of the appendix. This fold is peculiar in the absence of any visible vessels, and is often known as the 'bloodless fold of Treves.' Between it and the appendix there is an almost constant fossa, the *inferior ileo-cæcal fossa*. It is large, admitting two fingers. It opens outwards, and is bounded on one side by the small intestine, and on the other by the cæcum. The appendix is now and then found in the fossa.

The subcæcal or retrocolic fossa is behind the cæcum, and may extend for some distance behind the ascending colon. The appendix may be lodged in this fossa.

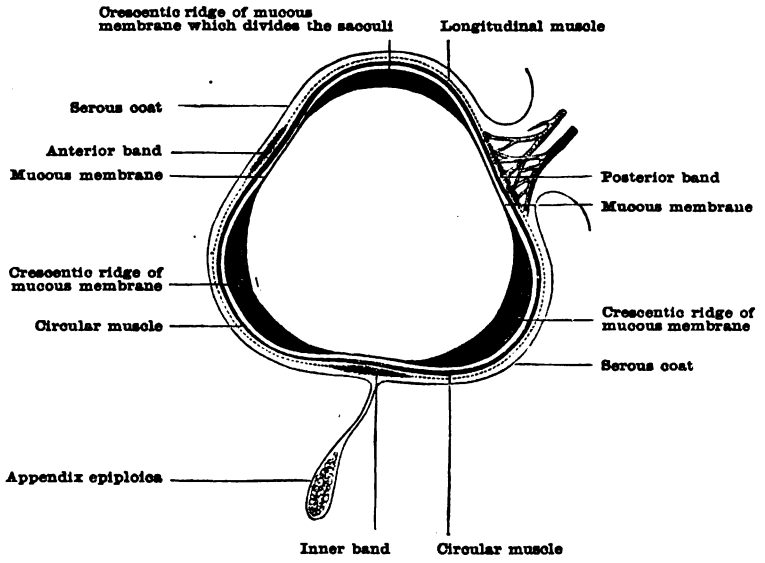
The ileo-cæcal valve.—The ileo-cæcal valve or valvula coli, which is situated at the entrance of the ileum into the large intestine at the upper border of the cæcum, is found on the posterior aspect and towards the inner side of the intestine. The ileum passes from below upwards and towards the right, and terminates with a considerable degree of obliquity. The valve is formed by two lip-like folds projecting into the large intestine, the upper being nearly transverse, the lower being a little oblique. The opening between them takes the form of a narrow slit about 1·2 cm. in length. At the ends of the slit the valves unite and are prolonged at

either end as a ridge partially surrounding the intestine (frena). Villi cover that surface of the folds looking towards the ileum; the surface towards the large intestine is free from villi. In the formation of this valve the longitudinal muscular fibres pass across from the ileum to the large intestine without dipping down between the two layers of each fold. The circular muscular fibres, on the other hand, are contained between the mucous and submucous layers which form these folds.

The colon.—In the adult the ascending and the descending parts of the colon are approximately vertical, while the direction of the transverse colon is practically horizontal. The average length in the adult of the ascending colon (as measured from the tip of the cæcum to the hepatic flexure) is 20 cm., and of the descending colon (as measured from the splenic bend to the commencement of the sigmoid loop) is 21·2 cm. The descending colon is the part of the large bowel that is least liable to variation. It is the only part of the gut except the duodenum that retains its original position as a portion of the great primary vertical loop. The transverse colon, on the other hand, is liable to considerable variation in length, position, and arrangement. Its average length is 50 cm. in the adult. It has been found to vary in adults from 30 to 87·5 cm.

The ascending colon.—The ascending colon extends from the cæcum to the

FIG. 807.—SECTION OF THE ASCENDING COLON. (Allen Thomson.)



inferior surface of the liver, external to the gall-bladder, forming there the right colic or hepatic flexure. It is covered by peritoneum in front and at the side, but in a certain proportion of cases (twenty-six per cent. in one hundred dissections) this part of the large intestine is connected with the posterior wall of the abdomen by a mesocolon—is, therefore, surrounded by peritoneum. Connected with the ascending colon is sometimes found a fold of peritoneum, extending from the right side of the gut to the abdominal wall at a little above the level of the highest part of the iliac crest. It forms a shelf upon which rests the extreme right margin of the liver. It might be called the *sustentaculum hepatis*.

The ascending colon is in relation behind with the right kidney, the second portion of the duodenum, and the quadratus lumborum. In front are some of the coils of the ileum (fig. 791).

The transverse colon.—The transverse colon, smaller in diameter than the ascending, extends from the under surface of the liver to the spleen. Being longer than a straight line between these two points, it has to describe an arch with its convexity forwards; it also bends a little downwards. It crosses through the umbilical region from the right hypochondrium to the left hypochondrium (fig. 791).

In the majority of cases the superficial part of the colic arch—as seen before the

viscera are disturbed—is either in whole or in greater part above a straight line drawn transversely across the body between the highest points of the iliac crest. In the proportion of one to four it lies, in whole or in greater part, below this line (fig. 814).

Certain remarkable bends are sometimes formed by this part of the bowel. The bending is always in the same direction, namely, downwards, and is usually abrupt and angular. The apex of the V or U-shaped bend thus formed may reach the pubes. This bend appears to be due to two distinct causes: namely, long-continued distension, on the one hand, and congenital malformation on the other.

The transverse colon is in relation above with the liver and gall-bladder, the stomach, and at its left extremity with the spleen. The third portion of the duodenum passes behind it. Below are the coils of the small intestine. It is surrounded with peritoneum, being connected with the posterior abdominal wall by a meso-colon.

The **descending colon** extends from the spleen to the sigmoid colon. It is more movable than the ascending colon. It is also narrower. At its beginning it is connected with the diaphragm, on a level with the tenth and eleventh ribs, by a fold of peritoneum, the *phreno-colic or costo-colic ligament* (or sustentaculum lienis, from the fact that it supports the spleen). The bend between the transverse colon and descending colon is called the left colic or splenic flexure. The descending colon is situated in the left hypochondriac and lumbar regions (fig. 808). Its relations to the peritoneum are the same as obtain with the ascending colon, that is, it is covered in front and on the sides. A meso-colon is met with oftener on this side than on the right. In one hundred dissections it was found thirty-six times. The descending colon is covered in front by the small intestine; behind, are part of the diaphragm, the left kidney, and the psoas and quadratus lumborum muscles (fig. 808).

The sigmoid colon and rectum.—The segment of gut termed the sigmoid colon, and the so-called first part of the rectum, form together a single simple loop that cannot be divided into parts. This loop begins where the descending colon ends, viz., in the left iliac fossa, and ends at the commencement of the so-called second portion of the rectum—at the spot where the meso-rectum ceases, opposite about the third sacral vertebra in the median line. The loop when unfolded describes a figure that may be compared to the capital omega. The average length of this sigmoid colon is 43 cm. The normal position of the loop is not in the left iliac fossa, but wholly in the pelvis. The most common disposition of it may now be described.

The descending colon ends just at the outer border of the psoas. The gut here suddenly changes its direction, and the sigmoid colon begins (figs. 791, 808). The bowel crosses the muscle at right angles about midway between the lumbo-sacral eminence and the inguinal (Poupart's) ligament. It now descends vertically along the left pelvic wall, and may at once reach the pelvic floor. It then passes more or less horizontally and transversely across the pelvis from left to right, and commonly comes into contact with the right pelvic wall. At this point it is bent upon itself, and, passing once more towards the left, reaches the middle line and descends to the anus. It will lie, therefore, in more or less direct contact with the bladder and uterus, and may possibly touch the cæcum. It is very closely related with the coils of small intestine that occupy the pelvis, and by these coils the loop is usually hidden.

The sigmoid colon is attached to the abdominal and pelvic wall by the sigmoid meso-colon, so that it is quite surrounded by peritoneum. The line of attachment of this meso-colon is as follows: It crosses the psoas at a right angle, and then takes a slight curve upwards so as to pass over the iliac vessels at or about their bifurcation. The curve ends at a point either just to the inner side of the psoas muscle, or between the psoas and the middle line, or, as is most frequently the case, just over the bifurcation of the vessels. From this point the line of attachment proceeds vertically down, taking at first a slight curve to the right. Its course is to the left of the middle line, while its ending will be upon that line, about the third sacral vertebra. The sigmoid meso-colon measures from 3 to 8·7 cm. in width—*i. e.*, from the parietes to the bowel.

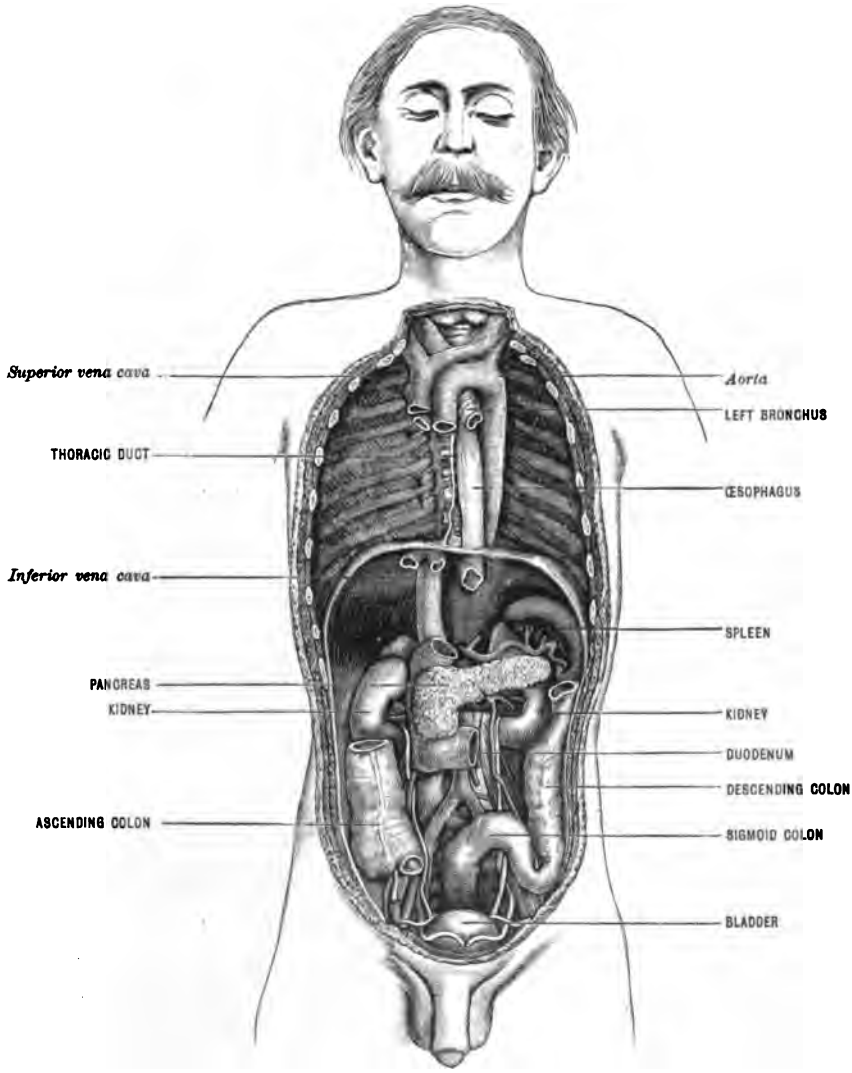
When a descending meso-colon exists, it joins that of the loop, and the line of attachment is then, as a rule, directed obliquely across the psoas and the lower end of the kidney, while beyond the pelvic brim the attachment is as above described.

There is often no meso-colon over the psoas, the gut being adherent to that muscle.

In connection with the sigmoid meso-colon is often found a fossa or pouch of peritoneum, known as the *intersigmoid fossa*. This pouch is formed by the layers of the meso-colon, and is produced by the sigmoid artery. It is generally found over the bifurcation of the iliac vessels. The pouch is funnel-shaped, and the opening looks downwards and to the left. It varies in depth from 2·5 to 3·7 cm., and is the seat of the sigmoid hernia.

The rectum.—The rectum has been described as divided into three portions.

FIG. 808.—VIEW OF THE DEEPER ABDOMINAL VISCERA. (Rüdinger.)



Such a division is quite arbitrary and is inconvenient. What is usually described as the first portion has, in the account just given, been included with the sigmoid colon.

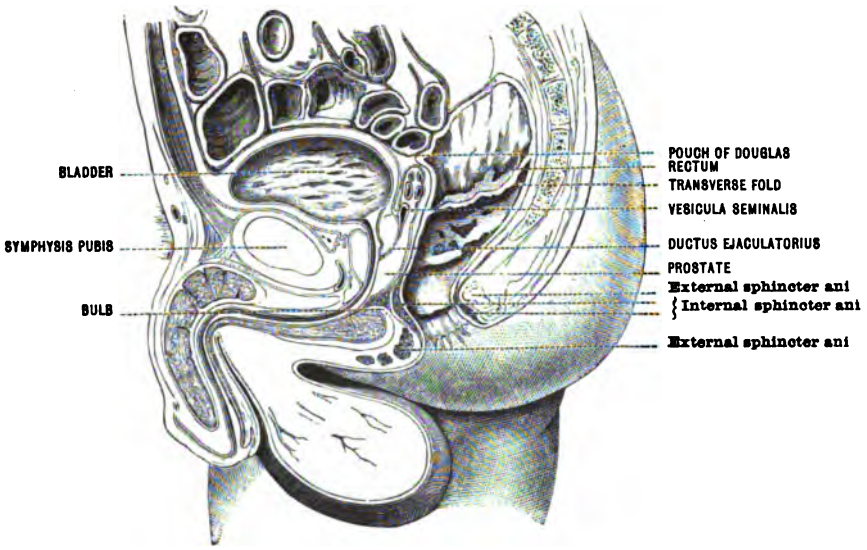
The two remaining portions of the intestine extend from the middle of the third sacral vertebra to the anus. In this description, therefore, the term 'rectum' is limited to that part of the large intestine which is situated below the level of the middle of the third sacral vertebra, and which is free of any meso-colon. It may be divided into two portions, the first of which extends from the middle of the third sacral vertebra to the apex of the prostate, the second from this point to the anus.

The first portion, about 8·7 cm. long, is only covered by peritoneum above, and then only over the anterior surface. Behind, it is in relation with the sacrum, coccyx, and ano-coccygeal body. In front, it is in relation with the trigone of the bladder, the vesiculæ seminales, the terminal parts of the vasa deferentia, and the under surface of the prostate. In the female the anterior surface is in relation with the vagina and the cervix uteri. The terminal portion is much dilated.

The peritoneum is reflected from the rectum to the bladder in the male, and the vagina in the female (recto-vesical or recto-vaginal pouch). This pouch extends in the male to within about 7·5 cm. of the anus. On the posterior surface of the gut there is no peritoneum below a point 12·5 cm. from the anus.

The anal canal or second portion extends from the apex of the prostate to the anus; it is about 3·7 cm. long. It differs from the first portion in the direction of its curve: while that follows the curve of the sacrum and coccyx, this portion turns backwards and downwards. It is not connected with the peritoneum. It is surrounded by the internal sphincter, while the levator ani is attached to its side. At its end the external sphincter is situated; in front is the uro-genital trigone of the perineum and the bulb of the urethra in the male, while in the female it is separated from the vagina by the perineal body.

FIG. 809.—SAGITTAL SECTION OF MALE PELVIS IN THE MESIAL LINE. (One-third.) (Braune.)



The anus.—The anus is the aperture by which the intestine opens externally. During life it is contracted by the sphincters, so as to give the skin around a wrinkled appearance. Around the lower part of the rectum and anus certain muscles that are connected with its proper function are situated. They are the internal sphincter, the levator ani, and the external sphincter. The levator ani and external sphincter will be found described in another part (Section X).

The *internal sphincter* is a thickening of the circular fibres of the intestine, situated round the second portion or anal canal. It forms a complete muscular ring. It is 2 to 3 mm. thick, and represents the thickened circular layer of the muscular coat, therefore is composed of non-striated muscle-cells.

The rectum differs from the rest of the colon in presenting perfectly smooth walls marked by no sacculi, by no longitudinal muscular bands, and by no appendices. Its mucous membrane is thicker than that of the rest of the large intestine. Certain folds, chiefly longitudinal in direction, are seen in the lax state of the tube, which disappear when distended, but Houston has described three permanent oblique **transverse folds,** containing bundles of non-striated muscle-cells, which project into the lumen of the tube: one is on the right at the level of the reflexion of the peritoneum from the rectum; and two are on the left, one above and one below the

right fold. That upon the right side is the largest and most constant, and is sometimes termed the *sphincter tertius*. It is situated from 7·5 to 8·7 cm. above the anus. The mucous membrane of the upper portion of the anal canal presents a series of vertical folds known as **rectal columns** (columns of Morgagni), containing bundles of non-striated muscle-cells longitudinally arranged. These columns become more prominent as they extend downwards. Just above the anus each two adjacent columns are united by an arch-like fold of mucous membrane, these folds forming what are known as the **anal valves,** while the small fossæ behind them are known as the **rectal sinuses.**

Structure of the large intestine.—There are four coats: a serous, muscular, mucous, and submucous.

The *serous* is derived from the peritoneum, and is more or less complete.

The appendices epiploicæ in connection with this layer have been mentioned (fig. 807).

The *muscular coat* is divided into circular and longitudinal layers, the longitudinal being external. The arrangement of the longitudinal fibres has been described in as far as they make up three longitudinal bands (fig. 807). Only a few longitudinal fibres are found between the bands, except on the vermiform appendix, the lower part of the sigmoid colon and the rectum, in which they are evenly distributed over the entire surface.

The circular fibres form a thin layer, and are mostly collected in the interval between the sacculi.

The *mucous membrane*, separated from the muscular layer by the *submucous layer*, has no villi and no plicæ circulares.

Blood-vessels.—The large intestine is supplied with blood by the branches of the superior mesenteric and inferior mesenteric arteries, while it also receives a blood-supply from the internal iliac at the rectum. The vessels form a continuous series of arches from the cæcum, where the vasa intestini tenuis anastomose with the ileo-colic, the first branch of the superior mesenteric given to the large intestine.

The blood-supply of the rectum is from the inferior mesenteric by the superior hæmorrhoidal, from the hypogastric (internal iliac) by the middle hæmorrhoidal, and from the internal pudic by the inferior hæmorrhoidal. The vessels at the lower end of the rectum assume a longitudinal direction, communicating freely near the anus, and less freely above.

The blood of the large intestine is returned into the portal vein by means of the superior mesenteric and inferior mesenteric veins. At the rectum a communication is set up between the systemic and portal system of veins, since some of the blood of that part of the intestine is returned into the hypogastric (internal iliac) veins. In the lower end of the rectum the veins, like the arteries, are arranged longitudinally. This arrangement is called the hæmorrhoidal plexus.

The **nerves** and **lymphatics** of the large intestine differ in no important particular from those of the small intestine.

Development of the rectum and anus.—The posterior end of the primitive intestine or archenteron, designated the hind-gut, presents a terminal portion which is somewhat dilated and known as the cloaca, into the lateral and ventral portion of which open the Wolffian ducts, and from the ventral portion of which arises the allantois. The ventral portion of the cloaca which is an entodermal structure, comes in contact with the ectoderm to form the cloacal membrane, and this forms the floor of a slight depression. For a time the cloaca or hind-gut extends for some distance caudal to the cloacal membrane, forming what is known as the post-anal gut; this, however, soon disappears. Early in the development of the human embryo, when this has attained a length of about 6·5 mm., the pouch-like fold which separates the cloaca and hind-gut from the allantois deepens, and folds develope from the lateral walls of the cloaca which meet and gradually separate the cloaca into a dorsal portion, which forms the rectum, and a ventral portion which forms the uro-genital sinus. This uro-rectal septum extends in its further growth until the cloacal membrane is reached, separating it into a ventral portion known as the uro-genital membrane, and a dorsal portion known as the anal membrane, the uro-rectal septum forming the perineum. The anal membrane ruptures comparatively late in development, establishing thus a communication between the hind-gut (rectum) and the exterior. The mesoderm developes around the lower end of the rectum, so that the ectoderm becomes slightly invaginated. A want of rupture of the anal membrane constitutes an arrest of development known as atresia of the anus.

THE LIVER

The **liver**—the largest gland in the body—is situated in the upper and right part of the abdominal cavity (figs. 791, 810). It is of irregular shape, and **weighs** between 1·2 and 1·7 kg., being smaller in females than in males. It bears a different relation to the body weight at different ages. It forms one-fortieth part of the weight of the body in the adult male, and one-thirty-sixth in the adult female; in the fœtus, at the fourth month, it is one-tenth the weight of the body, and in the infant at birth one-twentieth (fig. 810). It measures from right to left 17 to 25 cm., from before backwards 7·5 to 15 cm., and 15 to 17 cm. from above downwards in the thickest part of the right lobe. It is of a chocolate or reddish-brown colour, is solid and firm to the touch, but friable. Its bulk is equal to ninety-five cubic inches.

In the description which follows it will be noted that there are three **borders**—anterior, postero-superior, and postero-inferior; two **extremities**—right and left; three **surfaces**—superior, inferior, and posterior; **four lobes**—right, left, quadrate, and caudate or Spigelian, a process, known as the caudate process, arising from the last; five **fossæ** or **fissures**—the right sagittal fossa or fissure, which may be subdivided into the fossa for the gall-bladder and a fossa for the inferior vena cava; the left sagittal fossa or fissure, composed of the fossa for the umbilical vein, later, the ligamentum teres, and that for the ductus venosus, later, the ligamentum venosum (Arantii); and the transverse or portal fossa or fissure; **six ligaments**—coronary, falciform, the right and left triangular (lateral) ligaments, the ligamentum teres, and the ligamentum venosum.

The **anterior border** of the liver is well defined, appearing as a sharp, thin edge. To the left of the middle line is the umbilical notch, marking the division between the right and left lobes. Further to the right is a notch for the gall-bladder.

The two **posterior borders** separate the superior and inferior surfaces from the posterior, which is marked by the spinal column and grooved for the vena cava.

The **right extremity** is thick and rounded like the posterior border. The **left extremity** is thin and flat like the anterior border.

The **surfaces** are described as they are seen in a liver which has been hardened *in situ*.

The **superior surface** of the liver is convex, and moulded to the surface of the diaphragm. It is smooth and covered by peritoneum. It is divided by the falciform ligament, which runs from before backwards, into two parts: the **right** and **left lobes,** the right division being much the larger (fig. 811). Upon this surface of the left lobe is a shallow depression (*impressio cardiaca*) for the heart, and the surface of the lobe is much less convex than that of the right. A considerable portion of this surface faces anteriorly, and some writers divide it into anterior and upper surfaces.

The **inferior surface** consists of that part of the liver in front of and including the transverse or portal fissure. It is irregularly concave. It is covered by peritoneum, except where the gall-bladder comes in contact with its surface, and at the transverse or portal fossa, where the lesser omentum leaves the liver. It consists of three parts—viz., the quadrate lobe, nearly all the left lobe, and the under surface of the right lobe (fig. 812). This inferior surface is divided into right and left sections by the left sagittal fissure, which forms the inferior separation between the right and left lobes. The part of this fissure seen on this surface is known as the **umbilical fissure,** from its containing during fœtal life the left umbilical vein, the remains of which are now to be seen as the ligamentum teres. It runs from before backwards, meeting the portal fissure behind. The portion of the left lobe included on this surface is much smaller than the similar surface of the right lobe. It lies over the cardiac part of the stomach and the anterior surface adjoining the lesser curvature, and shows an impression (*impressio gastrica*) made by that organ. Its anterior border is sharp and free; but behind, the separation from the posterior surface is very ill defined.

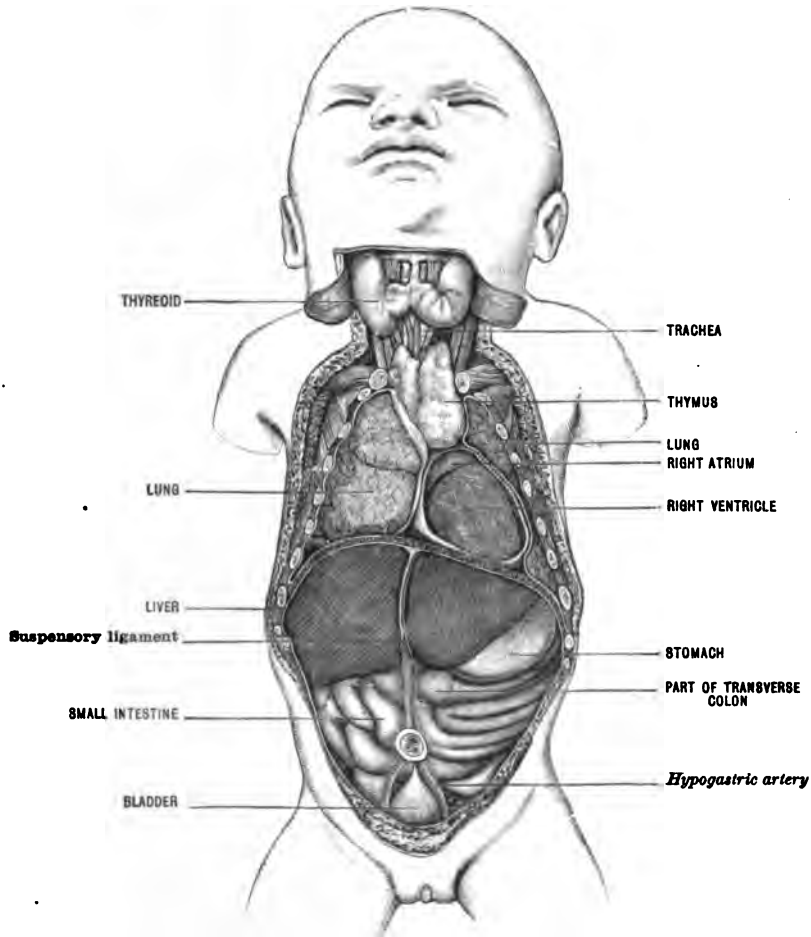
The under surface of the right lobe is divided into two by the gall-bladder, which is contained in a fossa (the *fossa of the gall-bladder*). The inner of these two portions, which is bounded by the umbilical fissure to the left, the fossa of the gall-bladder to the right, and the portal fissure behind, is called the **quadrate lobe,** and is connected with the left lobe very often by a bridge of liver substance (pons hepatis) across the umbilical fissure. The outer of the two portions is much the larger, and

presents three depressions upon its surface: an anterior one for the right colic flexure (*impressio colica*), a posterior one for the right kidney (*impressio renalis*), and one situated on the inner side of the impressio renalis for the descending part of the duodenum (*impressio duodenalis*). In a hardened liver these impressions are well marked and are separated by well-defined ridges.

The **posterior surface** is directed backwards towards the vertebral column, at which part it is concave. It includes that part of the liver behind the portal fissure and consists of the following parts (fig. 813):—

The posterior portion of the left lobe, not very well defined; it presents a protuberance (the *tuber omentale*) in front, which projects against the lesser omentum; behind, a concavity coming in contact with the cardiac portion of the stomach.

FIG. 810.—THE VISCERA OF THE FŒTUS. (Rüdinger.)



This portion is separated by means of the **fissure of the ductus venosus** from the **caudate** or **Spigelian lobe,** which lies between this fissure and that of the vena cava. This lobe is directed backwards, is longer from above downwards than from side to side, and is somewhat concave from side to side. It is opposite to the tenth and eleventh thoracic vertebræ, and rests on the right crus of the diaphragm. Behind its upper left-hand corner the œsophagus passes to enter the stomach. Below, it projects and forms part of the posterior boundary of the portal fissure. It is connected with that part of the right lobe which enters into the posterior surface by means of the **caudate process,** which is a small mass of liver substance running from left to right behind the portal fissure, and lying directly over the epiploic foramen (foramen of Winslow). It varies a good deal in form, being sometimes well defined,

at other times hardly to be seen; when well defined, it is about 5 to 7·5 cm. long. Behind it is the termination of the fissure of the vena cava.

The portion of the right lobe taking part in the posterior surface consists of a strip 6 to 7·5 cm. broad. This is uncovered by peritoneum, except at the extreme right. Lying between the two layers of the coronary ligament close to the vena cava

FIG. 811.—SUPERIOR SURFACE OF THE LIVER.

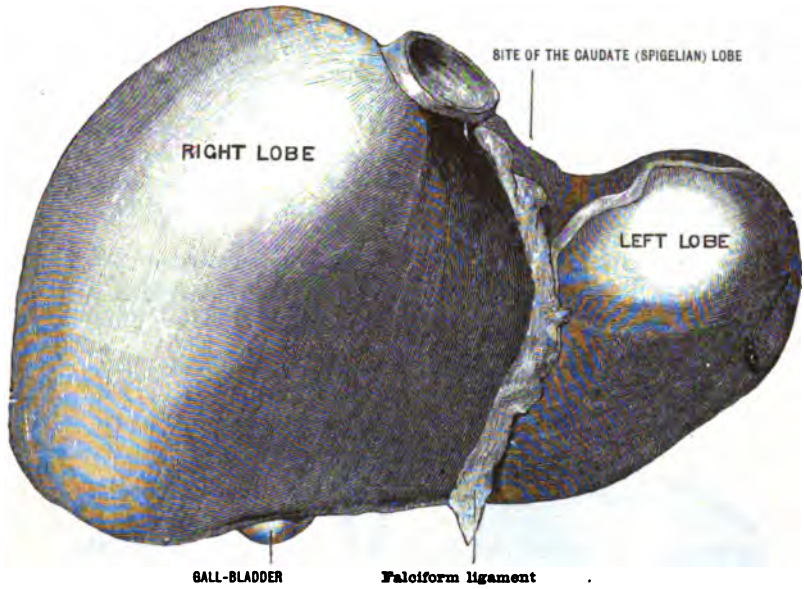
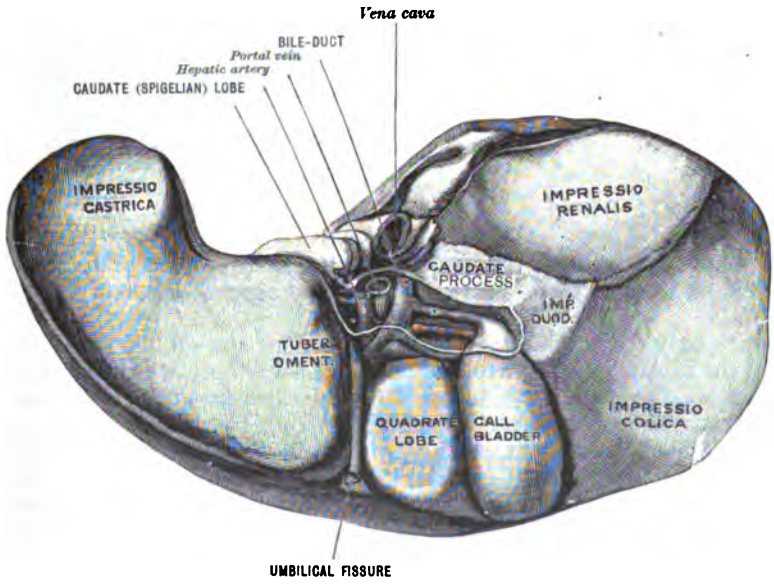


FIG. 812.—THE INFERIOR SURFACE OF THE LIVER.



and near the caudate lobe is an impression for the right suprarenal capsule (*impressio suprarenalis*).

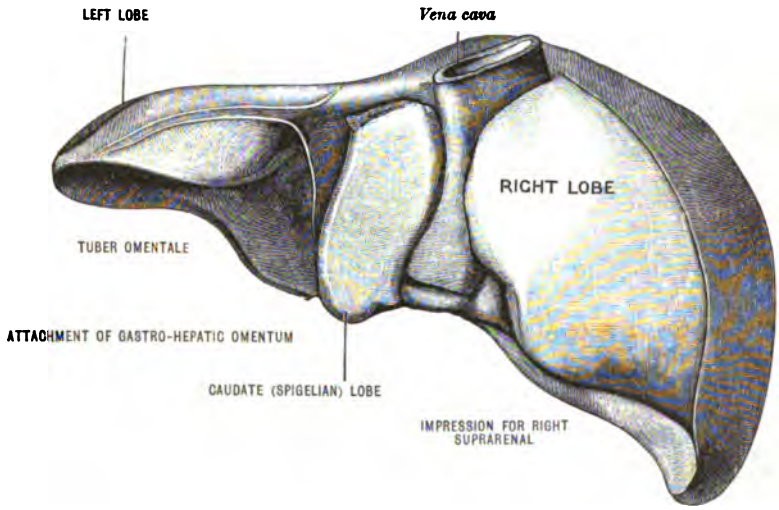
Fissures.—The fossæ or fissures on the inferior and posterior surfaces of the liver are arranged not unlike a capital letter **H**. The left upright of the **H** is formed by the left sagittal fissure; the anterior portion, containing the left umbilical vein and, after birth, the ligamentum teres, is seen on the inferior surface, and is known as the **um-**

bilical fissure; the posterior portion, seen on the posterior surface, contains the ductus venosus, after birth, the ligamentum venosum, and is called the **fissure of the ductus venosus.** The transverse bar of the H is formed by the **transverse** or **portal fissure (porta hepatis)**, which runs across at right angles to the left sagittal fissure, and contains the vessels entering the liver, viz., the portal vein, hepatic artery, and hepatic duct (fig. 812). The right upright of the H is formed by the right sagittal fissure, which is formed in front by the **fossa of the gall-bladder;** it is interrupted by the caudate process and is continued behind as the **fissure of the vena cava,** containing, as its name implies, the inferior vena cava.

General position.—The liver is situated in the right hypochondriac and epigastric regions, and usually extends into the left hypochondrium (fig. 814). It is opposite the ninth, tenth, and eleventh thoracic vertebræ behind (fig. 815), and on the right side extends between the seventh and eleventh ribs; in front, it lies behind the fifth, sixth, seventh, eighth, and ninth costal cartilages; and its anterior border corresponds on the right to the line of the margin of the costal cartilages, and crosses the subcostal triangle to pass beneath the eighth costal cartilage. It ends beneath the sixth costo-chondral junction (fig. 814).

The liver is very movable, and alters its position under various circumstances. It is depressed at each inspiration, the anterior border being pushed below the ribs by a deep breath. When lying down, the liver edge is about 1 cm. above the mar-

FIG. 813.—POSTERIOR SURFACE OF THE LIVER.



gin of the ribs. In children, the gland being larger in proportion to the body than in the adult state, it extends below the ribs and reaches the left hypochondrium (fig. 810).

The liver's extreme left point is about 6 cm. beyond the left margin of the sternum; in front, in the middle line, it reaches to about half-way between the xiphoid cartilage and the navel. The lower edge, as it crosses the subcostal angle, is represented by a line drawn from the ninth right to the eighth left costal cartilage. (Quain.)

Its upper limit is indicated by a line crossing the meso-sternum close to its lower end, and rising on the right side in the mammary line to the level of the fifth rib. On the left the line is practically horizontal. Behind, the liver is nearest the surface at the tenth and eleventh thoracic vertebræ.

Its upper convex surface is in contact with the whole of the right arch of the diaphragm and a part of the left, as well as with the ribs and the anterior wall of the abdomen.

The under surface of the left lobe lies over the cardiac end and a portion of the anterior wall of the stomach.

The right lobe lies over the right colic flexure and right kidney and descending portion of the duodenum.

The quadrate lobe lies over the pyloric end of the stomach and first part of the duodenum.

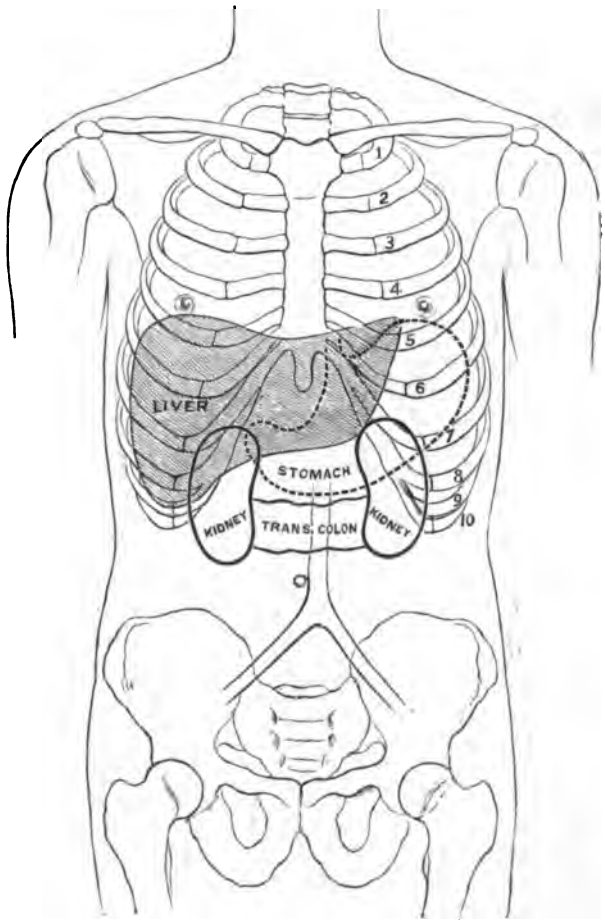
On the posterior surface the caudate (Spigelian) lobe lies against the tenth and eleventh thoracic vertebræ, the right crus of the diaphragm, and the lower end of the œsophagus. That portion of the right lobe which takes part in this surface lies against the right suprarenal capsule and diaphragm.

The inferior vena cava lies in a groove in this lobe. The small portion of the left lobe taking part in the posterior surface lies against the œsophagus.

The fundus of the gall-bladder is opposite the ninth costal cartilage, close to the outer margin of the right rectus muscle.

Relation to the peritoneum.—The relations of the liver to the peritoneum are discussed in part in considering the development of the peritoneum and of the liver; the relations of the fully developed liver to the peritoneum may yet receive brief mention. The anterior layer of the gastro-hepatic omentum passes on to the liver,

FIG. 814.—RELATION OF THE ABDOMINAL VISCERA TO THE ANTERIOR PARIETES. (Treves.)



encloses the left lobe, and forms the left layer of the falciform ligament and the left half of the upper and lower layers of the coronary ligament. The posterior layer of the gastro-hepatic omentum continues on to the liver, encloses the right lobe, and forms the right layer of the falciform ligament and the right half of the upper and lower layers of the coronary ligament.

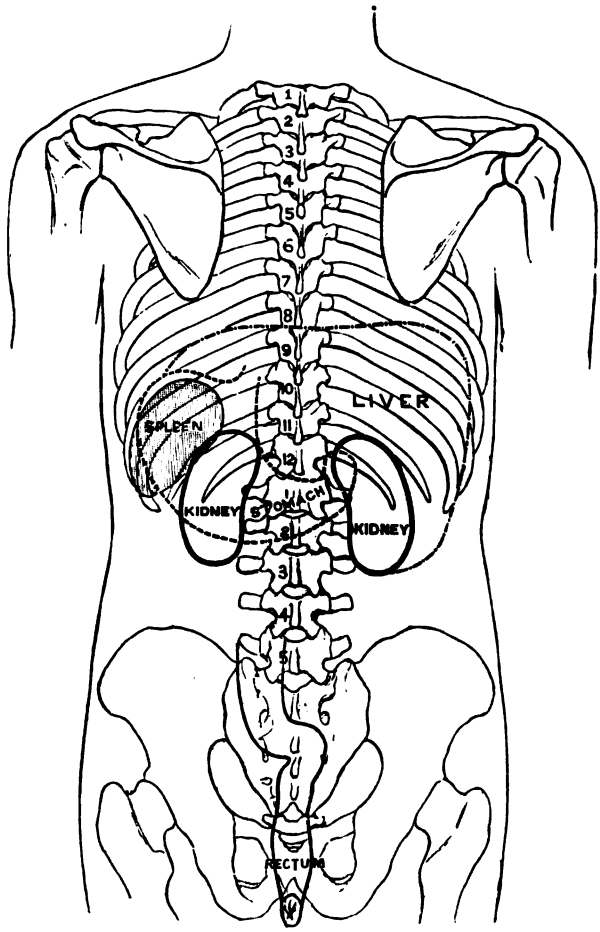
The parts of the liver uncovered by peritoneum are, therefore:—the portal fissure, generally the fossa of the gall-bladder, and that portion of the posterior surface made up by the right lobe known as the phrenic area.

Underneath the peritoneal investment of the liver is a fibro-elastic membrane which is intimately adherent to the peritoneum, and is continuous over the liver where the peritoneum is deficient. At the portal fissure this fibrous layer invests the

hepatic vessels, forming a special sheath which follows the vessels as they enter the liver: this structure receives the name of Glisson's capsule.

Ligaments of the liver.—The majority of the ligaments of the liver (all excepting the ligamentum teres and the ligamentum venosum) are formed by the peritoneum. The reflexion of the two layers of peritoneum from the posterior surface of the liver to the diaphragm, as just described, forms the **coronary ligament** whose extremities, or lateral continuations, are called the **right** and **left triangular (lateral) ligaments.** The left triangular ligament is the longer, and is attached to the diaphragm in front of the œsophagus. The right is attached to the back part of the diaphragm. The **falciform ligament** is continuous behind with the coronary ligament; it is formed by the adjacent surfaces of the two portions of peritoneum cover-

FIG. 815.—RELATIONS OF THE ABDOMINAL VISCERA TO THE POSTERIOR PARIETES. (Treves.)



ing the superior surface, and extends from the umbilicus, where is the apex of the falx. The upper rounded border is connected with the anterior abdominal wall and diaphragm; the free or anterior border contains the ligamentum teres; the lower or attached border extends from before backwards on the upper surface of the liver. The **ligamentum teres** and the **ligamentum venosum** represent obliterated embryonic veins. The former, formed from the left umbilical vein, extends on the free border of the falciform ligament from the left sagittal fossa to the umbilicus, while the latter, derived from the ductus venosus, is situated in the fossa of the ductus venosus, the posterior portion of the left sagittal.

Blood-vessels.—The liver receives its *arterial* supply of blood from the hepatic artery, a branch of the cœliac, which passes up between the two layers of the gastro-hepatic omentum, and, dividing into two branches, one for each lobe, enters the liver at the portal fissure. The

right branch gives off a branch to the gall-bladder. The liver receives a much larger supply of blood from the *portal vein*, which conveys to the liver blood from the stomach, intestines, pancreas, and spleen. It enters the portal fissure, and there divides into two branches. Below this fissure the hepatic artery lies to the left, the bile-duct to the right, and the portal vein behind and between the two (fig. 816). These three structures ascend to the liver between the layers of the gastro-hepatic omentum in front of the epiploic foramen. At the actual fissure the order of the three structures from before backwards is—duct, artery, vein.

The *hepatic veins*, by which the blood of the liver passes into the inferior vena cava, open by several large and small openings into that vessel at the posterior surface of the gland at the bottom of the fossa of the vena cava.

Lymphatics.—The lymphatics are divided into a deep and a superficial set. The *deep set* runs with the branches of the portal vein, artery, and duct through the liver, leaving at the portal fissure, where they join the vessels of the superficial set. The efferent deep vessels after leaving the portal fissure pass down in the gastro-hepatic omentum in front of the portal vein, where there is a chain of lymphatic nodes, and ultimately end in a group of nodes at the upper border of the neck of the pancreas, in which the pyloric lymphatics also terminate.

The *superficial set* begin in the subperitoneal tissue. Those of the upper surface consist:—(1) Of vessels which pass up, principally, in the falciform ligament and right and left triangular ligaments, through the diaphragm, and so into the anterior mediastinal nodes; occasionally lymphatics of the right triangular ligament pass straight into the thoracic duct. (2) Of a set passing over the anterior border of the liver to the nodes in the gastro-hepatic omentum about the portal fissure.

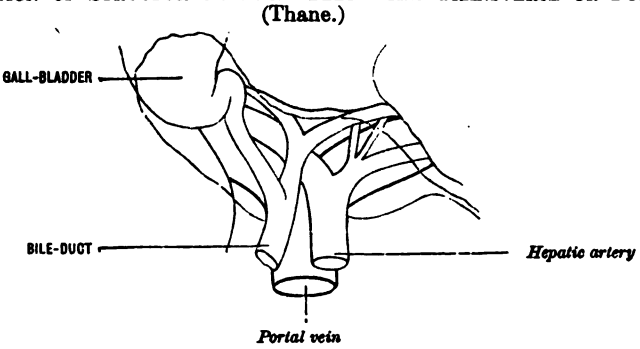
On the under surface, the lymphatics to the right of the gall-bladder enter the lumbar nodes.

Those around the gall-bladder enter the nodes of the gastro-hepatic (lesser) omentum.

Those to the left of the gall-bladder enter the nodes of the œsophagus and lesser curvature of the stomach.

Structure of the liver.—The liver is, for the greater part, covered by peritoneum, beneath which is found the fibro-elastic layer known as Glisson's capsule. At the portal fissure Glisson's

FIG. 816.—RELATION OF STRUCTURES AT AND BELOW THE TRANSVERSE OR PORTAL FISSURE. (Thane.)



capsule passes into the substance of the liver, accompanying the portal vessels, the branches of the hepatic artery, and the bile-ducts. The liver substance is composed of vascular units measuring from 1 to 2 mm., and known as liver lobules. These are in part (man) separated by a small amount of interlobular connective tissue, which is a continuation of Glisson's capsule. In this interlobular connective tissue are found the terminal branches of the portal vessels, the hepatic artery, and the bile-ducts. The branches of the portal vessels which encircle the liver lobules are known as the interlobular veins. From these are given off hepatic capillaries, which anastomose freely, but have in general a direction towards the centre of the lobule, and unite to form the central or intralobular veins, which in turn unite to form the sublobular veins, and these the hepatic veins. The intralobular branches of the hepatic arteries form capillaries which unite with the capillaries of the intralobular portal veins. The liver-cells are arranged in anastomosing cords and columns occupying the spaces formed by the hepatic capillaries. The bile-ducts have their origin in so-called bile-capillaries, situated in the columns of liver-cells; they anastomose freely and pass to the periphery of the lobules to form the primary divisions of the bile-ducts, and these unite to form the larger bile-ducts. The branches of the portal vessel are accompanied in their course through the liver by the branches of the hepatic artery and the bile-ducts, surrounded by extensions of Glisson's capsule. The branches of the hepatic vein are solitary, their walls are thin and closely adherent to the liver substance, whence they remain wide open on sectioning the liver.

Shortly after the formation of the entodermal bud which forms the liver this mass of epithelium becomes penetrated by outgrowths from the omphalo-mesenteric veins, reducing the epithelial mass to anastomosing trabeculæ separated by blood-spaces forming a sinusoidal circulation. The definite hepatic lobules are not differentiated until after birth.

The **gall-bladder,** which retains the bile, is situated between the right and quadrate lobes on the under surface of the liver. It is of pyriform outline, and when full, is seen projecting beyond the anterior border of the liver, coming in contact

with the abdominal wall opposite the ninth costal cartilage. It extends back as far as the portal fissure.

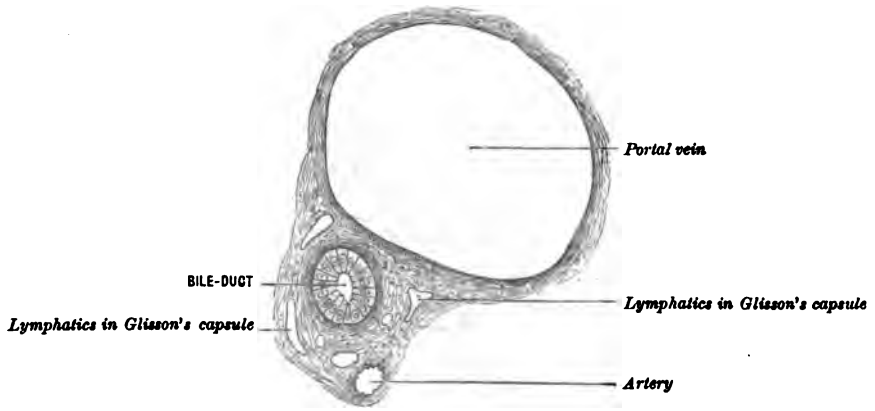
It measures in length, from before backwards, from 7·5 to 10 cm., and 3·5 cm. across at the widest part, and will hold about 34 c.cm. The broad end of the sac is directed forwards, downwards, and to the right, and is called the *fundus*. The narrow end, or *neck*, which is curved first to the right, then to the left, lies within the gastro-hepatic omentum at the portal fissure. The intervening part is called the *body*.

Its *upper surface* is in contact with the liver, lying in the fossa of the gall-bladder. It is attached to the liver by connective tissue. The lower surface is covered by peritoneum, which passes over its sides and inferior surface, though occasionally it entirely surrounds the gall-bladder, forming a sort of mesentery to attach it to the liver. The lower surface comes into contact with the first part of the duodenum and the right colic (hepatic) flexure, and occasionally with the pyloric end of the stomach or small intestine, which *post mortem* are often found stained with bile.

The neck of the gall-bladder opens into the *cystic duct*. This is a tube 3·5 cm. long and 2·3 mm. wide, which unites with the hepatic duct to form the ductus choledochus; it is directed backwards and to the left as it runs in the gastro-hepatic omentum, the common hepatic artery being to the left and the right branch of the artery and portal vein behind. It joins the hepatic duct at an acute angle, and is kept patent by a spiral valve (*valve of Heister*), formed by its mucous coat.

The *hepatic duct* begins with a branch from each lobe, right and left, in the portal

FIG. 817.—SECTION OF A PORTAL CANAL. (Quain.)



fissure, and is directed downwards and to the right in the folds of the gastro-hepatic omentum, the right branch of the hepatic artery being behind and the left branch to the left. It is not quite 5 cm. long; its diameter is about 4 mm. Uniting with the cystic duct, it forms the *common bile-duct* or ductus choledochus.

The **ductus choledochus** or **common bile-duct** is about 7·5 cm. in length. It passes down between the layers of the gastro-hepatic (lesser) omentum, in front of the portal vein, and to the right of the hepatic artery (fig. 816); it then passes behind the first part of the duodenum, then between the second part and the head of the pancreas, being almost completely imbedded in the substance of the pancreas, and ends at the lower part of the second segment of the duodenum by opening into that part of the intestine on its left side and somewhat behind (figs. 798, 818, 819). It pierces the intestinal wall very obliquely, running between the muscular layer for a distance of about 1·8 cm. There is a slight constriction at its termination. The pancreatic duct is generally united with the ductus choledochus just before its termination, and there is a slight papilla at their place of opening on the mucous surface of the duodenum. This papilla is about 10 cm. from the pylorus. After the pancreatic duct has entered the bile-duct there is a dilatation of the common tube called the **ampulla of Vater.**

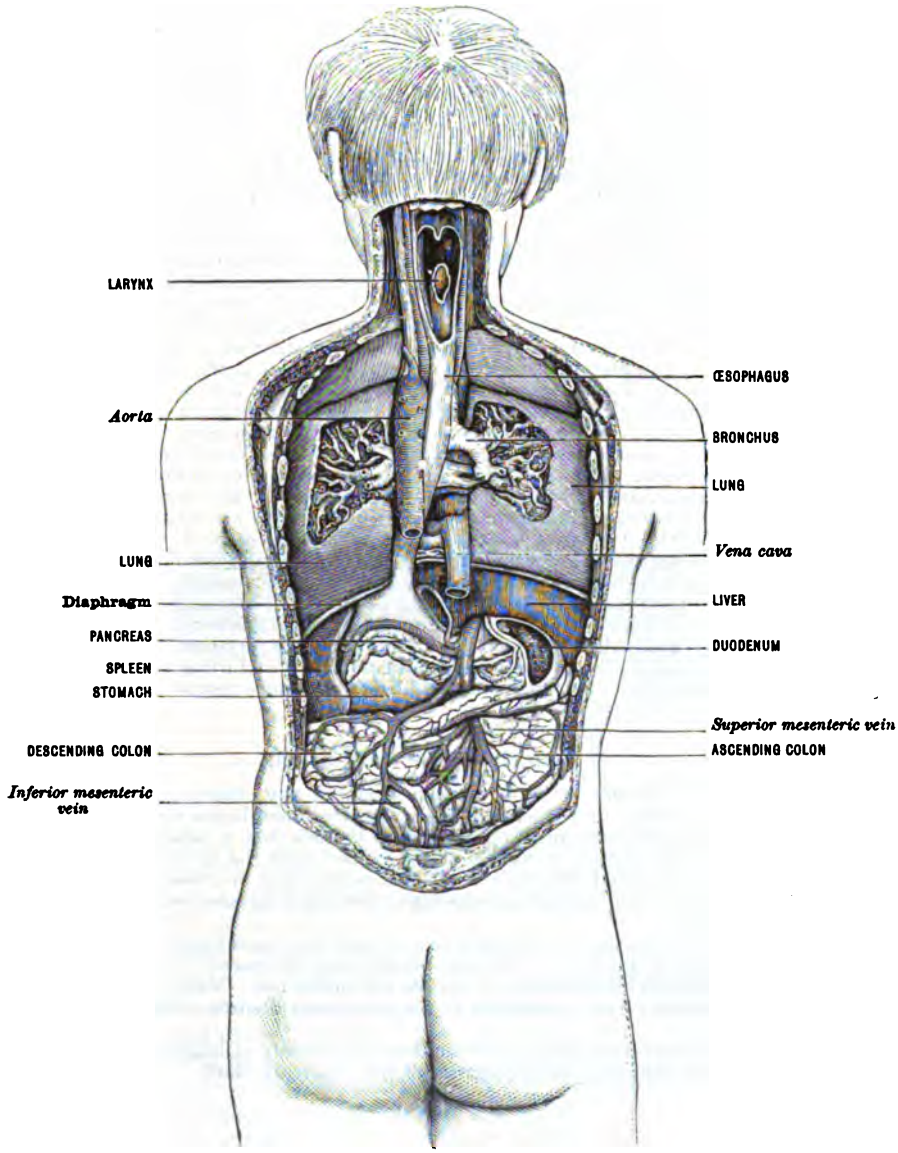
The ductus choledochus has a diameter of about 6 mm. Its width at the ampulla is greater. It is narrowest at its outlet into the duodenum. The cystic and hepatic ducts are considerably narrower than the common duct.

Structure of the gall-bladder.—The wall of the gall-bladder is made up of three coats—serous, fibro-muscular, and mucous.

1. The *serous coat* being formed by the peritoneum, is only found on the lower surface and part of the sides.

2. The *fibro-muscular coat* consists of interlacing bundles of non-striated muscle-cells and fibrous tissue not definitely arranged, the muscular bundles running longi-

FIG. 818.—ABDOMINAL VISCERA, FROM BEHIND. (Rüdinger.)



tudinally and obliquely. This layer contains the principal blood-vessels and lymphatics, and also a nerve plexus.

3. The *mucous coat* is raised into folds bounding polygonal spaces, which are largest about the body. It is lined with columnar epithelium, and contains many mucous glands and lymph-nodules, and is limited externally by a poorly developed muscularis mucosæ. At the neck the mucous membrane forms folds which project into the interior, acting as valves. This layer contains an anastomosis of blood-

vessels, the capillaries being most numerous in the folds of the mucosa, and a fine plexus of lymphatics.

The *ducts* consist of a fibro-muscular and a mucous layer. In the fibro-muscular layer are non-striated muscle-cells which are chiefly circular, together with white fibrous tissue and elastic fibres. The mucous layer is lined with columnar epithelium, and has many mucous glands. In the cystic duct the mucous membrane is raised into folds, which are crescentic in form, and directed so obliquely as to seem to surround the lumen of the tube in a spiral manner.

The development of the liver.—The relations which the liver bears to the diaphragm, to its vessels and more especially the veins, and to its so-called ligaments, may be understood by a reference to its development. In discussing the development of the peritoneum and the mesenteries it was shown that the liver has its origin in a bud of entoderm, which grows into the transverse septum in the region where this is attached to the ventral mesoderm of the developing intestine, and that, with further development, the transverse septum differentiates into an upper thinner portion, inclosing the Cuvierian ducts, and destined to form the diaphragm, and a lower thicker portion in which the liver developes. The liver rapidly enlarges, filling the upper portion of the abdominal cavity, and extending along its ventral wall to the region of the umbilicus. During the enlargement it in a measure outgrows the transverse septum, and there are developed grooves which result in an infolding of the peritoneum covering the transverse septum, and which in part separate the developing liver from that part of the septum destined to form the diaphragm, and also from the ventral abdominal wall. These grooves appear at the sides and also ventral to the liver, but do not completely separate the liver from the diaphragm, nor do they meet in the median line. A portion of the liver, therefore, remains uncovered by peritoneum, and remains attached to the diaphragm; this area may be known as the phrenic area of the liver. Around this area the peritoneum of the liver is reflected on to the diaphragm, forming the coronary ligament, with right and left extensions, designated as the right and left triangular ligaments. Owing to the fact that the grooves which develope on the sides of the liver do not meet in the median line, there persists a fold of peritoneum which attaches the liver to the ventral abdominal wall; this forms the falciform ligament, which divides the superior surface of the liver into a right and a left lobe. The region of the attachment of the ventral mesoderm of the intestinal canal into which grows the entodermal bud from which the liver developes, forms the gastro-hepatic or lesser omentum. The developing liver early comes into intimate relation with the omphalo-mesenteric veins, and a little later the umbilical veins. The developmental history of these veins and their relation to the developing liver is discussed elsewhere (see DEVELOPMENT OF THE PORTAL VEIN AND INFERIOR VENA CAVA, p. 685). After birth the left umbilical vein forms the hepatic ligamentum teres, situated in the free edge of the falciform ligament.

The gall-bladder has its origin in a groove lined by entoderm, which appears on the ventral surface of the primitive intestine or archenteron, between the stomach and the yolk-vesicle. From the cephalic end of this groove grows out the bud destined to form the liver; the caudal end of the groove becomes gradually separated from the developing intestine to form a pouch, lined by entoderm, which forms the beginning of the gall-bladder. With further growth the attachment to the intestine of both the liver and the gall-bladder becomes narrowed to form the ductus choledochus.

VARIATIONS OF THE LIVER

Variations are less frequent in the liver than in almost any other organ of the body. The left lobe may be very small; on the other hand, it may be much larger than usual, occasionally extending in an attenuated form much more towards the left than is usual. In the newly born and not unfrequently in women, it may come in contact with the spleen. The left lobe, or a portion of it, may be attached only by a pedicle of peritoneum and vessels to the main organ. The gall-bladder has been seen through an opening in the upper surface, owing to the depth of the fossa of the gall-bladder.

The liver may be subdivided into many lobes, or may show no division at all. It may retain the thick rounded form of the fœtus. The gall-bladder may be absent, in which case the hepatic duct usually becomes much dilated before it reaches the duodenum. Many of the supernumerary fissures seen on the human liver correspond to the permanent fissures of the typical mammalian liver. (Thomson.)

The gall-bladder may be partially divided either transversely or longitudinally. The ductus choledochus may enter the bowel independently of the pancreatic duct.

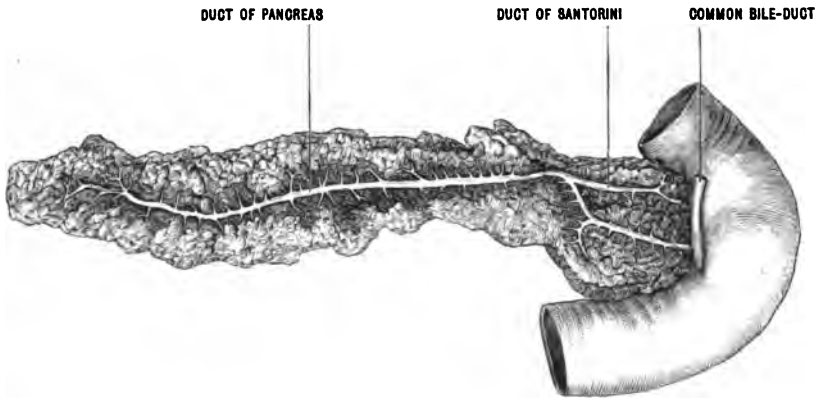
THE PANCREAS

The **pancreas** is situated in the epigastric and left hypochondriac regions. It is a compound alveolar gland. It lies transversely across the body, on a level with the first and second lumbar vertebræ, and is deeply placed (fig. 808). It differs in shape as it is examined *in situ* or removed from the body. When examined *in situ*

it shows various impressions for the different organs with which it is in contact (figs. 797, 798); when removed from the body it appears to be longer, and runs to a point at the left extremity (fig. 819). It is of a greyish-red colour and soft in texture, and it shows surface markings which bound the lobules of which it is made up. The pancreas varies considerably in size. Its average length is 12 to 15 cm., and its thickness from 1·2 to 2·5 cm. It weighs from 66 to 100 gm. It may be divided into three portions:—a head, a body, and a tail. The **head of the pancreas** is situated at the right extremity of the gland, and is contained in the loop of the duodenum. It is disc-shaped and flattened from before backwards, and is bent downwards, so that it extends lower than the lower border of the body. Behind it are found the common bile-duct, which runs, as a rule, in a canal in its substance, the vena cava, the left renal vein, and the aorta (fig. 798). In front are the superior mesenteric vessels, the pancreatico-duodenal vessels, and the transverse colon and its meso-colon. The head of the pancreas then becomes narrower, forming a portion which is sometimes spoken of as the neck of the pancreas; it extends upwards and to the left to join the body. This narrow portion lies over the point of junction of the superior mesenteric and portal veins and is grooved by the gastro-duodenal and superior pancreatico-duodenal arteries. In front of it would be the first part of the duodenum.

The **body of the pancreas** presents three surfaces—anterior, inferior, and posterior—and extends from the head of the gland to the spleen; it is situated transversely across the vertebral column with the large vessels intervening.

FIG. 819.—THE PANCREAS AND ITS DUCTS.



The *anterior surface* is in contact with the stomach, which organ gives a concavity to the surface (fig. 797). This surface is covered by peritoneum derived from the ascending layer of the transverse meso-colon.

The *posterior surface* is in contact with the crura of the diaphragm, the aorta, and superior mesenteric vessels, which structures are interposed between it and the spine (figs. 798, 818). The splenic artery and vein run lengthways above the back of the upper border, and, to the left, the posterior surface is in contact with the left kidney and suprarenal capsule. The upper border in the middle line abuts against the cœliac artery.

The *inferior surface* is narrow, and lies over the fourth part of the duodenum and beginning of the jejunum. The transverse meso-colon is continued from the front of the head along the border separating this surface from the anterior surface. The splenic end of the transverse colon lies under the left extremity of this surface. From the under surface of the transverse meso-colon a layer of peritoneum passes to the central part of the inferior surface. The posterior surface is devoid of peritoneum.

The **tail of the pancreas** is the name given to the left extremity of the organ; it touches the lower part of the inner surface of the spleen.

The **pancreatic duct,** or the canal of Wirsung, runs from nearly the extreme left of the gland, concealed by its substance, nearer its posterior surface than the anterior, and between the upper and lower borders, to empty into the lower and inner part of the second portion of the duodenum with the common bile-duct. It runs sinuously, re-

ceiving its branches as it goes, which enter nearly at right angles. Its diameter near its termination is from 2 to 3 mm. Near its termination the pancreatic duct lies in close relation with the ductus choledochus, the two piercing the wall of the duodenum obliquely, to terminate either by two separate openings or after fusion by a common opening. An accessory pancreatic duct (duct of Santorini) is often present. This joins the main pancreatic duct in the head of the pancreas, and may open separately into the duodenum, from one to two centimetres from the main duct. These variations are readily explained from the development of this gland. Besides the alveoli of the pancreas, which are in connection with the duct system, there are found certain interalveolar masses known as the *areas of Langerhans*. These areas are developed from the same tissue from which is developed the gland tissue, but in their further growth become completely separated from the tubules. They have a distinct blood-supply, consisting mainly of venous spaces, and may be regarded as masses of gland tissue having an internal secretion.

Blood-supply.—The pancreas receives blood from the splenic artery through its pancreatic branches, and from the superior mesenteric and hepatic by the inferior and superior pancreatico-duodenal arteries, which form a loop running around, below, and to the right of its head.

The blood is returned into the portal vein by means of the splenic and superior mesenteric veins.

Lymphatics.—The lymphatics terminate in numerous glands which lie near the root of the superior mesenteric artery, above and below the neck of the pancreas.

Nerves.—These are branches of the cœliac plexus which accompany the arteries entering the gland. The main part of the cœliac plexus lies behind the gland.

Development of the pancreas.—The pancreas has its origin in three entodermal buds, one of which grows from the dorsal portion of the duodenum, the other two from either side of the bile-duct. Of the two latter, only that growing from the right side of the bile-duct needs further consideration, as the other soon disappears. The dorsal bud grows at first more rapidly than the ventral, which arises from the bile-duct. In their further growth both the dorsal and ventral buds become lobed, these lobes dividing further to form the ducts and the alveoli of the gland. By about the end of the second month the distal end of the ventral portion comes in contact with the dorsal portion at a short distance from the latter's insertion in the duodenum. A fusion of the two portions thus takes place in this region, and at the same time there is established by anastomosis a connection between the terminal branches of the main duct of the dorsal portion —duct of Santorini—and the branches of the main duct of the ventral portion—the duct of Wirsung. With further development the duct of Wirsung developes into the main pancreatic duct, the duct of the dorsal portion (duct of Santorini) either losing its connection with the duodenum or remaining as the accessory pancreatic duct. During the early stages in the development of the pancreas the entodermal buds from which it forms grow into the meso-duodenum, and later the meso-gastrium. With the rotation of the stomach and the consequent change in the position of the meso-gastrium and its partial fusion with the abdominal wall, the pancreas assumes a retroperitoneal position.

SECTION IX

THE RESPIRATORY ORGANS

ORIGINALLY WRITTEN BY ARTHUR HENSMAN, F.R.C.S., AND ARTHUR ROBINSON, M.D., F.R.C.S.
REWRITTEN FOR THE FOURTH EDITION

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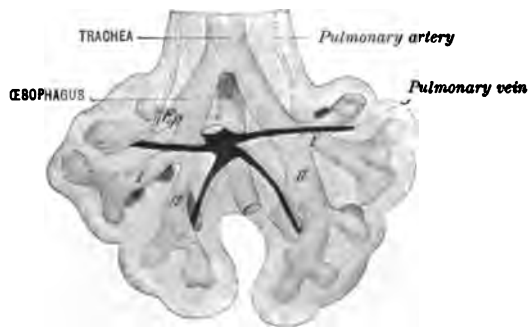
RESPIRATION consists in the absorption of oxygen, which is necessary to life, and the discharge of a waste-product, carbon dioxide.

Among unicellular animals the oxygen is taken up directly from the medium—water or air—in which they live, and the carbon dioxide given off into it. With the cells which make up the body of higher animals the process is the same, but the interchange of gases is indirect. The blood stands as an intermediate element between the cells of the body and the medium inhabited by the animals, and serves as a carrier of the gases between them. Moreover, special organs are provided for the rapid interchange between air and blood, which constitute the so-called **respiratory system.**

FIG. 820.—RECONSTRUCTION OF THE LUNG OUTGROWTH OF AN EMBRYO 10.5 MM. (After His.)
Ep. Apical bronchus. I–II. Primary bronchi.



The respiratory system of air-breathing vertebrates consists of tubular and cavernous organs into which air is drawn and upon the walls of which the blood circulates in vascular networks. Such organs are called **lungs** (fig. 820). The paired lungs of man derive their systems of branching tubes from a single median tube which leads from the ventral wall of the pharynx. While the greater portion of this tube, the **trachea,** is a simple transmitter of air to and from the lungs, the upper part, the **larynx,** is specially constructed as the organ of the voice.

The organs of circulation are always adapted to the form of the respiratory apparatus, and among all higher animals a connection is established between heart and lungs by the pulmonary artery, which carries venous blood to the latter, and by the pulmonary veins, which convey arterial blood from the lungs to the heart, whence the aorta takes it into the general circulation.

The respiratory organs originate as a ventral outgrowth of the digestive tube, and there are many evidences, even in the adult, of the genetic relationship of the digestive and respiratory systems besides their actual connection in the throat.

The larynx is situated in the neck and is connected with the hyoid bone and the pharynx; the lungs fill the greater part of the thoracic cavity, while the trachea is partly in the neck and partly in the thorax. In the latter are certain serous membranes: the **pleural sacs,** which invest the lungs, and the **pericardium,** which envelopes the heart. Their cavities are separated parts of the primitive cœlom.

THE LARYNX

The larynx is a tubular organ, the walls of which are made of cartilages and elastic membranes covered within by mucosa; from the latter structures are formed a pair of **vocal folds** (cords) which, by the passage of air through the larynx, are thrown into vibration and so function in the generation of sound; these folds are

FIG. 821.—VIEW OF INTERIOR OF LARYNX AS SEEN DURING INSPIRATION.

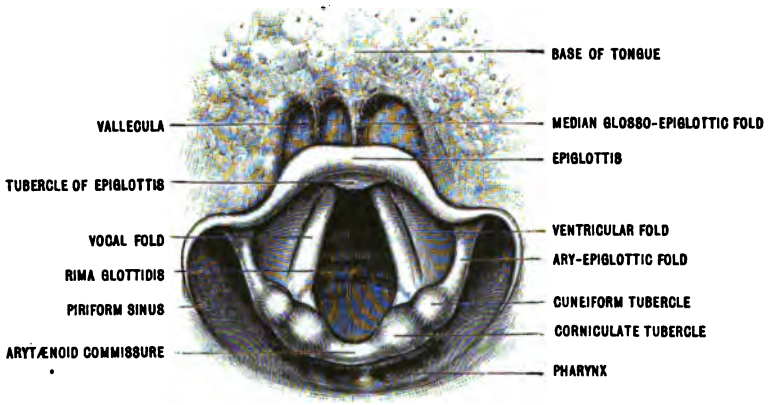
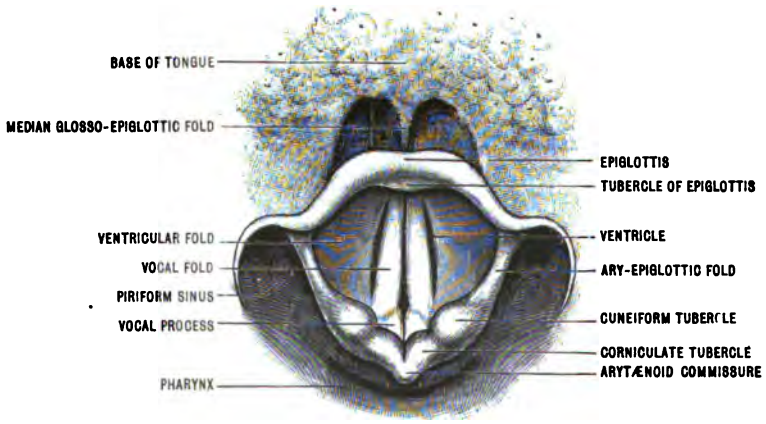


FIG. 822.—VIEW OF INTERIOR OF LARYNX AS SEEN DURING VOCALISATION.

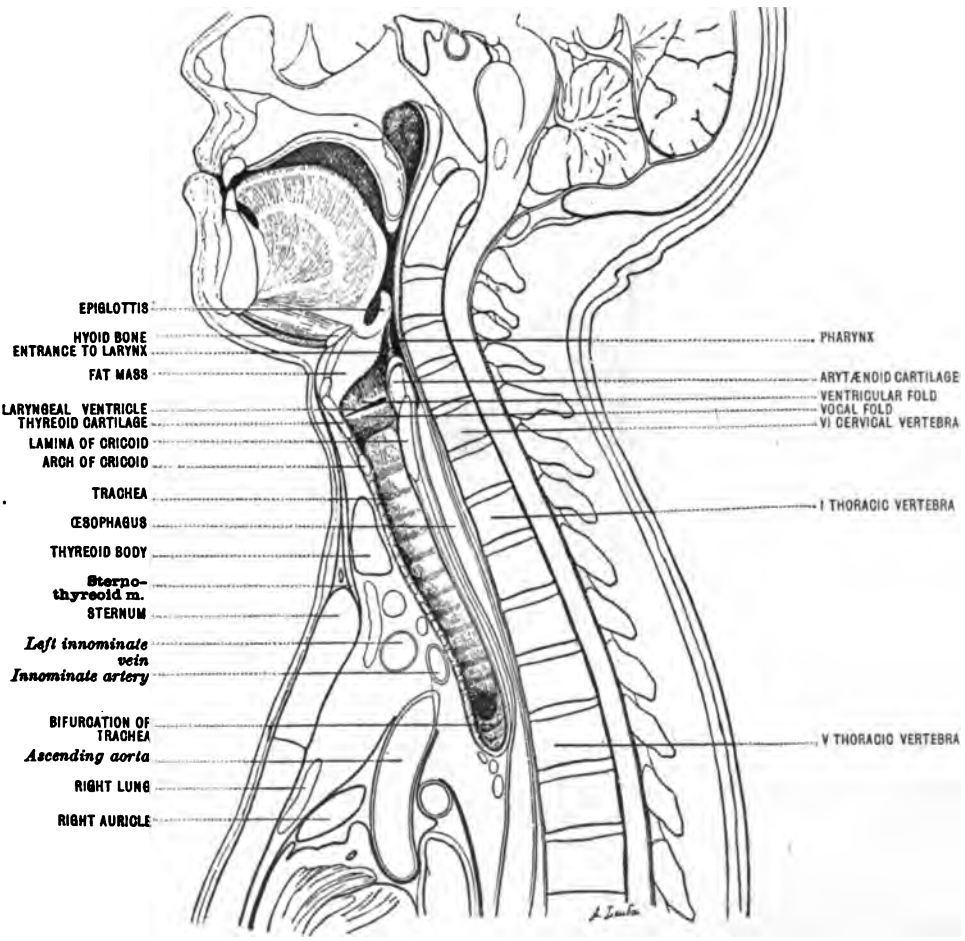


regulated in respect to their state of tension and in their mutual relation by a system of laryngeal muscles under the control of the vagus nerve.

Position and relations.—The larynx opens above into the pharynx by the aditus, or superior aperture, and in this region is connected with the hyoid bone. Below, its cavity leads into the trachea. Its position in the neck is indicated by the eminence called Adam's apple, and it stands in front of the fourth, fifth, sixth, and seventh cervical vertebræ; from these it is separated by the prevertebral muscles and the pharynx, into the anterior wall of which it enters. The integuments and cervical fascia cover the larynx anteriorly in the middle line, while more to the side are the sterno-hyoid, sterno-thyreoid, and thyreo-hyoid muscles. The lateral lobe of the thyreoid gland and the inferior constrictor of the pharynx are in relation to it laterally, while farther removed are the great vessels and nerves of the neck.

When viewed with the laryngoscope, the following parts can be seen (figs. 821, 822):—The base of the tongue; the entrance to the larynx bounded in front by the epiglottis, laterally by the ary-epiglottic folds in which are the eminences over the cuneiform and corniculate cartilages, posteriorly by the commissure between the tips of the arytænoids; within the entrance, the vestibule with the cushion of the epiglottis in front and the ventricular folds overhanging the ventricles at the sides; below them the vocal folds and intervening rima glottidis; far down, the cricoid and the anterior wall of the trachea; with widely dilated rima glottidis, the bifurcation of the trachea.

FIG. 823.—MEDIAN SECTION OF A MAN 21 YEARS OF AGE, SHOWING THE POSITION OF LARYNX AND TRACHEA. (After W. Braune, from Poirier and Charpy.)



The relations of the larynx and some of its important parts can be well seen in a median section (fig. 823).

THE CARTILAGES OF THE LARYNX

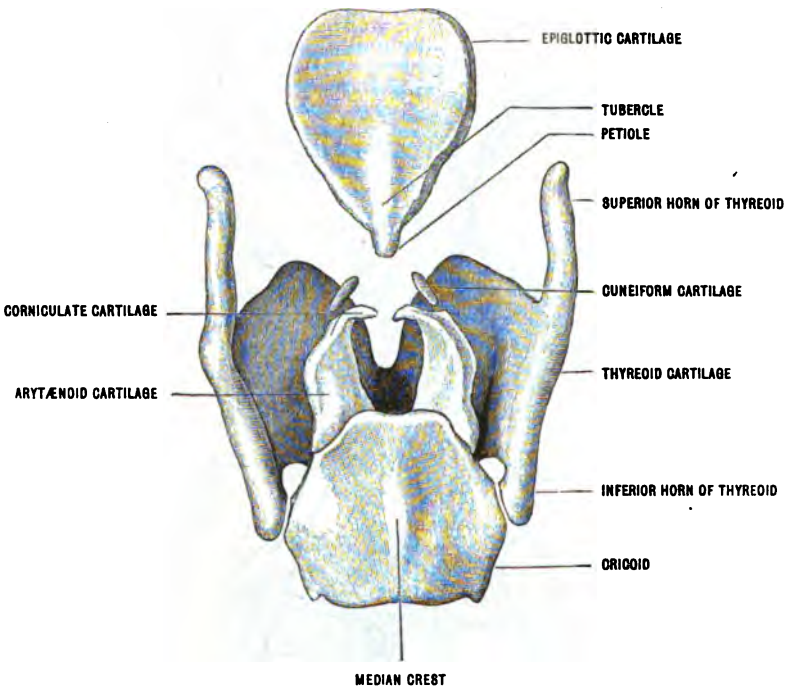
The number of cartilages entering into the framework of the larynx is nine, three of which are single and the rest in pairs.

The **cricoid cartilage** (figs. 824, 825, 826, 828), single, has been compared in its shape to a signet ring. Its position is at the lower end of the larynx, and it is connected with the first ring of the trachea. Posteriorly the cricoid cartilage expands into a broad lamina, which enters into the posterior boundary of the laryngeal cavity, while laterally and in front it forms a narrow **arch.** On either side of the upper margin of the lamina is an elliptical articular facet, its long axis parallel with the margin of the cricoid, its surface convex for articulation with the arytænoid

cartilage. The hinder surface of the lamina presents a median ridge and lateral impressions for the attachment of muscles—the posterior crico-arytænoid. The arch is weakest in its middle part; its superior margin is oblique, its inferior, horizontal. A circular, elevated facet for articulation with the inferior cornu of the thyreoid cartilage is situated upon the side of the cricoid where arch and lamina are continuous. The internal surface is covered by the laryngeal mucosa.

The **thyreoid cartilage** (figs. 824, 825, 826, 827), single and the largest in the laryngeal skeleton is composed of two broad **laminæ,** which meet and are fused anteriorly in the mid-line in a right angle, partly covering the other cartilages laterally and in front. The laminæ are stout, but their connection at the angle is through a

FIG. 824.—CARTILAGES OF THE LARYNX SEEN FROM BEHIND IN THEIR NATURAL POSITIONS. THE CUNEIFORM CARTILAGE IS SOMEWHAT HIGHER THAN NORMAL. (Merkel.)



weak strip of cartilage. The upper margin of each lamina is convex, and in front drops abruptly to form in the median line the **superior thyreoid notch.** The anterior edges meeting in the angle produce the **laryngeal prominence,** which is seen on the front of the neck. The horizontal inferior margin presents near its middle the **inferior thyreoid tubercle,** and in the median line the **inferior thyreoid notch.** The thick posterior margin of each lamina is continued above the superior edge in the long **superior cornu,** and below the inferior margin in the short **inferior cornu.** The former is directed slightly backwards and inwards, and is connected with the end of the greater cornu of the hyoid bone by ligament. The inferior horn, curving inwards as it descends, articulates by a flat, circular facet upon the inner side of its extremity with the thyreoid articular surface of the cricoid cartilage. The external surface of the lamina is marked by the **oblique line,** having in its upper part the **superior thyreoid tubercle** and in its lower part the inferior thyreoid tubercle. The surfaces in front and behind this line afford attachment to muscles. The internal surface of the thyreoid cartilage is smooth.

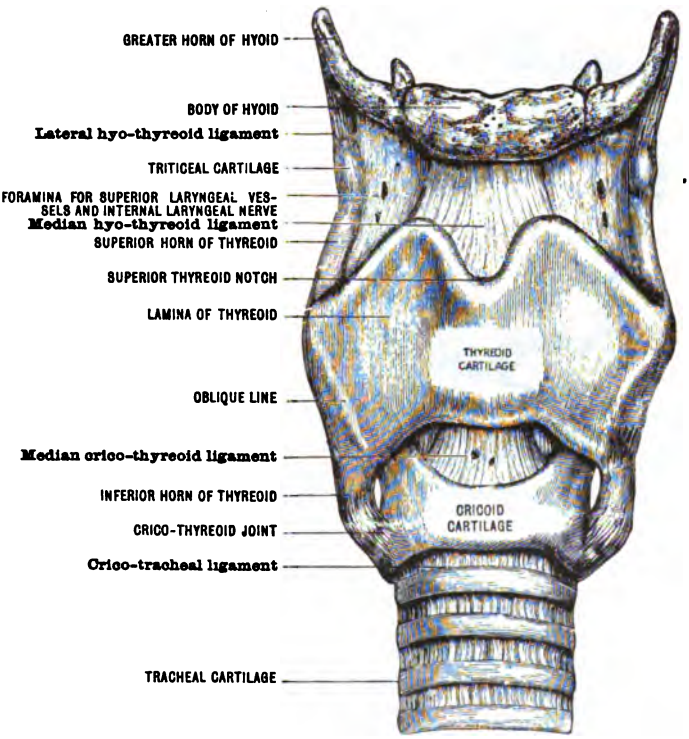
A thyreoid foramen, sometimes seen in the upper part of the lamina, giving passage to the superior laryngeal artery, results from the incomplete union of the fourth and fifth branchial cartilages from which the laminæ are derived.

The **arytænoid cartilages** (figs. 824, 827, 828, 829), paired, surmount the lamina of the cricoid cartilage and give attachment to the vocal ligaments, the relations and

tension of which are altered by the changes in position which the arytænoid cartilages are almost constantly undergoing.

Each cartilage is pyramidal in form, and moulded for the attachment of several muscles. The **apex,** which is above, is bent backwards and inwards, and articulates with a corniculate cartilage. The **base,** somewhat triangular in shape, presents at the external and posterior part an oval or circular concave facet, directed inwards and downwards for articulation with the cricoid cartilage. The lateral angle of the base is prolonged into a stout **muscular process** for the attachment of the crico-arytænoid muscles, while the anterior angle is extended as a sharp projection, the **vocal process,** which serves for the attachment of the vocal ligament. The surfaces are named medial, posterior, and antero-lateral. The narrow **medial surface,** covered by the mucosa of the larynx, is nearly vertical, and faces the corresponding side of the opposite arytænoid, from which it is separated by a small space. The **posterior**

FIG. 825.—FRONT VIEW OF THE LARYNGEAL SKELETON. (Modified from Bourgery and Jacob.)



surface is concave for muscular attachment. The **antero-lateral surface** is the largest, and presents an irregular contour: a ridge, the *arcuate crest,* extends horizontally between two hollows—the *triangular fovea* above, which lodges some mucous glands, and a larger depression, the *oblong fovea,* below for the vocal muscle.

The corniculate cartilages (cartilages of Santorini) (figs. 824, 827).—These are a pair of little conical cartilages set upon the bent apices of the arytænoids, continuing their curves backwards and inwards.

The corniculate cartilage is not independent of the arytænoid in lower animals, and its continuity with the arytænoid is sometimes met with in man where the two cartilages are normally developed in a continuous mass of tissue.

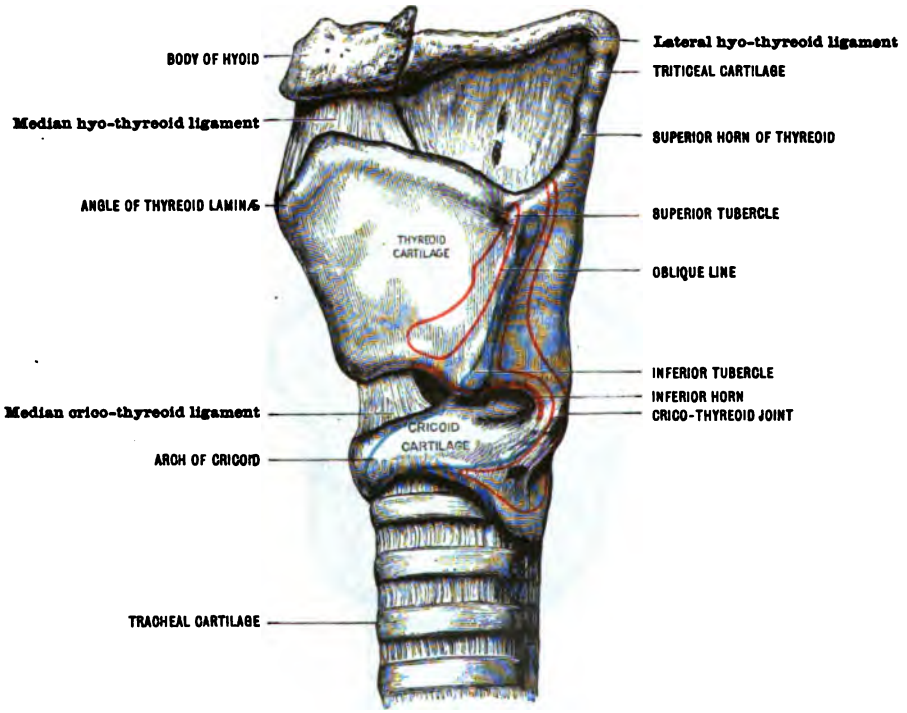
The **epiglottic cartilage** (figs. 824, 827, 832, 837), unpaired, invested by mucosa behind and partly in front, thin and leaf-shaped, stands behind the root of the tongue and the body of the hyoid. It is above the thyreoid cartilage, in front of the entrance of the larynx. The free upper margin is convex, or notched; the lower end tapers to a short stalk, the **petiole,** to which the thyreo-epiglottic ligament is attached.

The anterior surface is free in its superior part; in its lower part it is bound to the body of the hyoid, and is separated by a mass of fat from the hyo-thyreoid ligament. Its posterior surface above is saddle-shaped; below, it is convex, presenting the **tubercle.** To the margins are attached the ary-epiglottic folds. The epiglottic cartilage presents numerous small holes and depressions for the accommodation of glands.

The **cuneiform cartilages (cartilages of Wrisberg)** (fig. 824) lie as small, rod-like bodies in the ary-epiglottic folds anterior to the cartilages of Santorini. They are not always present.

These are parts of the epiglottic cartilage in lower animals where, as in man, they lie in the ary-epiglottic folds. Their relations to the arytænoids are regarded as secondary. Sutton has shown that in the ant-eater a continuous rim of yellow elastic cartilage extends from the sides of the epiglottic cartilage to the summits of the arytænoids.

FIG. 826.—SIDE VIEW OF THE LARYNGEAL SKELETON. (Modified from Bourgery and Jacob.)



Structure of the cartilages.—The thyreoid, cricoid, and greater part of the arytænoid are composed of hyaline cartilage, while the epiglottic, corniculate, and cuneiform cartilages, as well as the apex and vocal process of the arytænoid, are of elastic cartilage. Ossification begins at about twenty years of age in the thyreoid and cricoid cartilages, and later in the arytænoid. The process begins a little later in the female than in the male, and does not extend so rapidly. The elastic elements are not involved in the ossification.

THE JOINTS AND FIBROUS MEMBRANES OF THE LARYNX

(1) CONNECTIONS BETWEEN THE LARYNGEAL CARTILAGES

The crico-thyreoid articulation (figs. 824, 825, 826, 827, 828).—The articular surfaces concerned are the rounded facet on the side of the cricoid and that on the inferior horn of the thyreoid cartilage. An articular capsule attached around the margins of these surfaces and certain accessory bands serve to bind the cartilages together. The accessory bands, the *cerato-cricoid ligaments*, radiate from the inferior horn, one upwards and medianwards to the superior margin of the cricoid;

another downwards at the side and back of the capsule; a third downwards and forwards. The capsule is lined by a synovial membrane. A rotary movement

FIG. 827.—THE LARYNGEAL SKELETON SEEN FROM BEHIND. (Poirier and Charpy.)

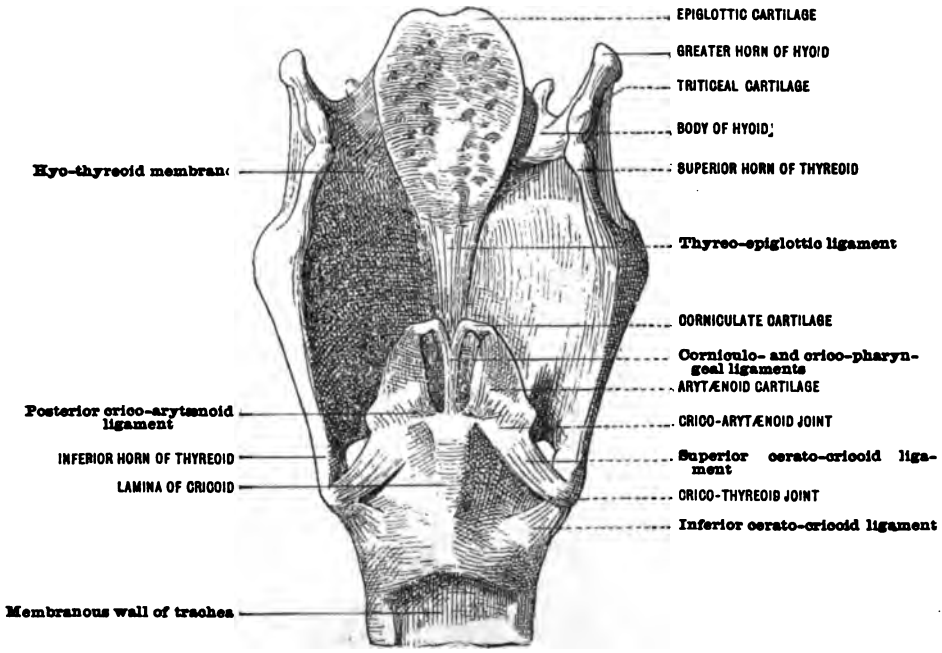
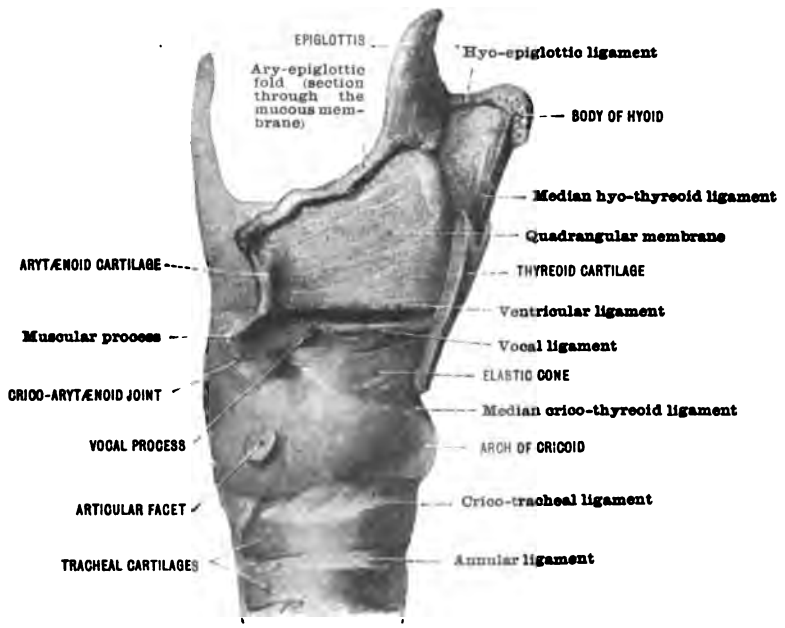


FIG. 828.—THE LARYNX WITH ITS LIGAMENTS, VIEWED FROM THE RIGHT. (The right lamina of the thyreoid cartilage has been removed.) (Spalteholz.)



of the cricoid or thyreoid about a transverse axis and a slight backward and forward gliding are permitted at this joint.

The crico-arytænoid articulation (figs. 824, 827, 828, 829).—The articular

surfaces of the arytænoid and cricoid cartilages are so disposed that at no time are they in complete apposition. A loose capsule lined by synovial membrane and attached around the edges of the joint surfaces connects the cartilages. A *posterior crico-arytænoid ligament*, attached above to the medial surface of the base and muscular process of the arytænoid, and below to the lamina of the cricoid, prevents slipping of the arytænoid and limits its movements. The movements allowed are—(1) a gliding of the arytænoid towards or away from its fellow; (2) an inclining forwards and backwards; (3) rotation on a vertical axis, so that the vocal process sweeps inwards or outwards and also a little downwards or upwards.

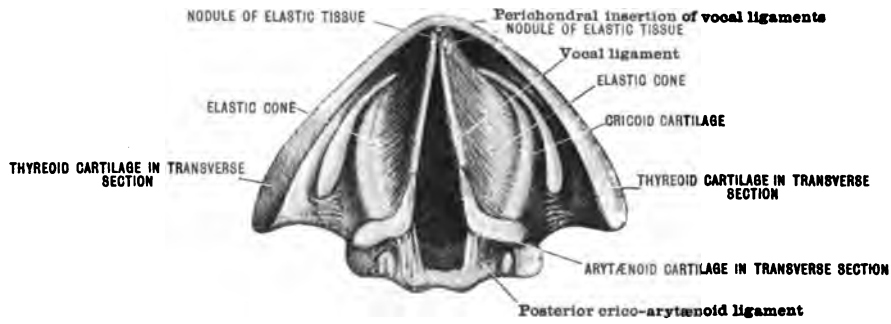
The union of the corniculate cartilage with the apex of the arytænoid cartilage is usually by connective tissue; rarely there is a joint cavity.

The epiglottic cartilage is connected with the thyreoid, below and behind the superior notch, by a strong, elastic *thyreo-epiglottic ligament* (fig. 827).

(2) The Elastic Membrane of the Larynx. (Lauth.)

This name is given to a more or less continuous sheet of elastic fibres connected with the deeper parts of the laryngeal mucosa. Its upper part is known as the quadrangular membrane, the lower part as the elastic cone. A middle region of the elastic membrane corresponds to the ventricle of the larynx.

Fig. 829.—The Elastic Cone seen from Above. (Modified from Luschka.)

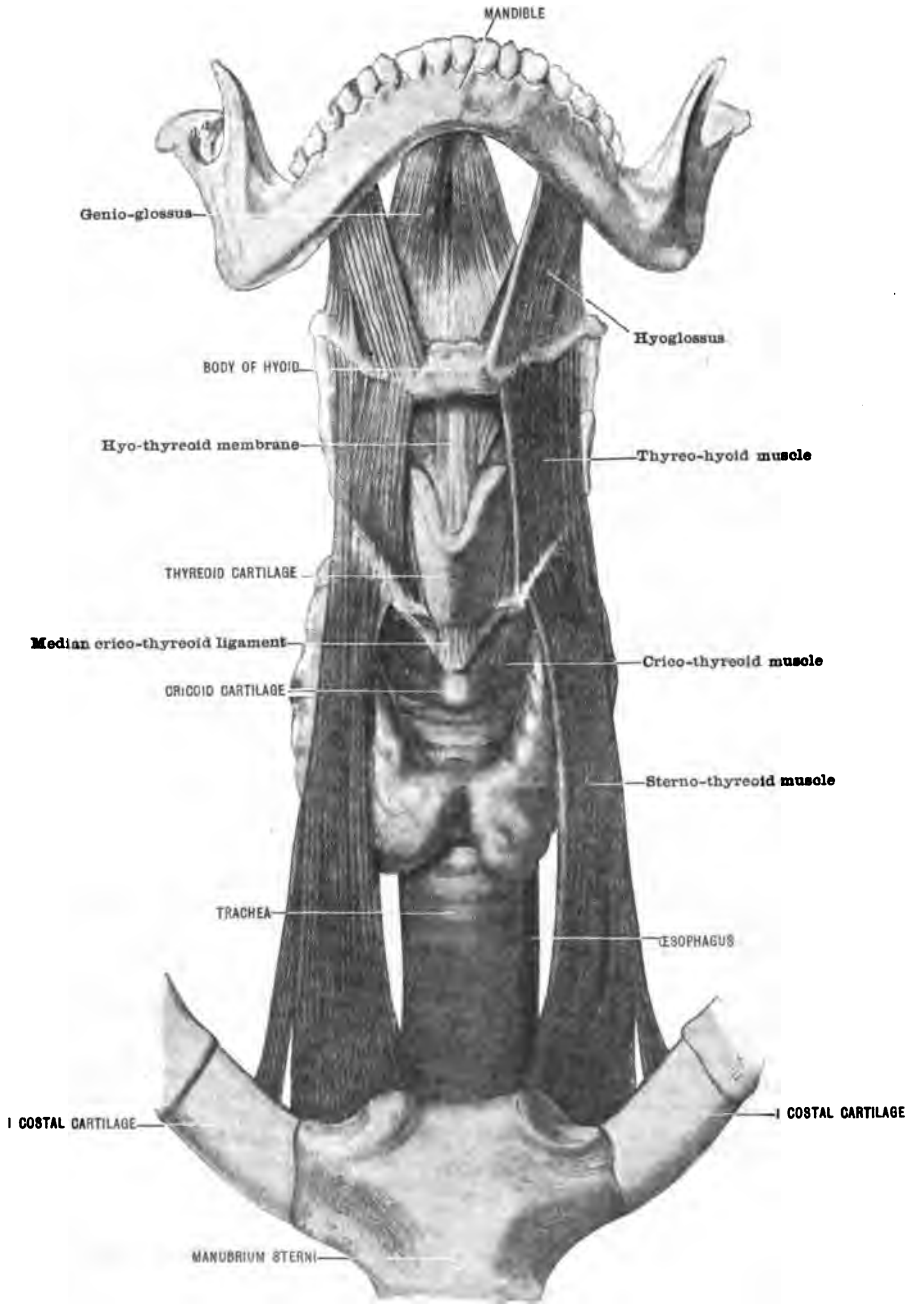


The **quadrangular membrane** (figs. 828, 832, 838) extends from the ary-epiglottic folds above to the level of the ventricular folds (false vocal cords) below. Superiorly, the lateral parts of this membrane are widely separated, but they converge towards the middle line as they descend. Anteriorly, the membrane is fixed in the angle of the thyreoid laminæ and to the sides of the epiglottic cartilage; posteriorly, to the corniculate cartilages and to the arytænoids. The superior edge lies within the ary-epiglottic fold, which it supports; it slopes downwards and backwards and includes the cuneiform cartilage. The inferior edge is horizontal and in a sagittal plane; it is best developed in front, and is attached in the angle of the thyreoid a little way from the middle line; behind, to the inner margin of the triangular fovea of the arytænoid. This inferior free margin constitutes the **ventricular ligament** (superior thyreo-arytænoid ligament), and it is enclosed by the ventricular fold (false vocal cord).

The elastic cone (figs. 828, 829).—This part of the elastic membrane extends from the level of the vocal folds to the superior border of the cricoid cartilage. Its component fibres are attached in the re-entrant angle and adjacent lower border of the thyreoid cartilage, whence they spread downwards and backwards to the upper edge of the cricoid arch and to the arytænoid cartilages. The strong anterior portion, perforated by vessels, is the *median crico-thyreoid ligament* (figs. 825, 826). The lateral parts (lateral portions of the crico-thyreoid membrane) present superior free edges, thickened a little, which, running horizontally near the middle line from the thyreoid angle to the vocal processes, constitute the **vocal ligaments.** Anteriorly they are inserted into a perichondral process in the thyreoid angle; posteriorly, the ligaments have a wide area of attachment to the upper and medial

surfaces of the vocal processes, with the elastic fibres of which they are in part continuous. A nodule of elastic tissue (sometimes cartilage) occurs in the anterior end of each ligament. The vocal ligaments lie in the vocal folds (true vocal cords).

FIG. 830.—THE EXTRINSIC MUSCLES OF THE LARYNX. (The crico-thyreoids are also shown.) (Modified from Luschka.)



(3) CONNECTIONS BETWEEN THE LARYNX AND NEIGHBOURING STRUCTURES

The **hyo-thyreoid membrane** (figs. 827, 830, 831, 832) is a loose, fibrous, elastic sheet, binding together the thyreoid cartilage and hyoid bone. It extends from the margin of the former to the greater horns and superior margin of the body of the

latter. The superior laryngeal artery and vein and the internal laryngeal nerve pass through it from the side. Its posterior and lateral edge is cord-like, consisting of

FIG. 831.—THE LARYNX SEEN FROM THE LEFT SIDE. (Modified from Luschka.)

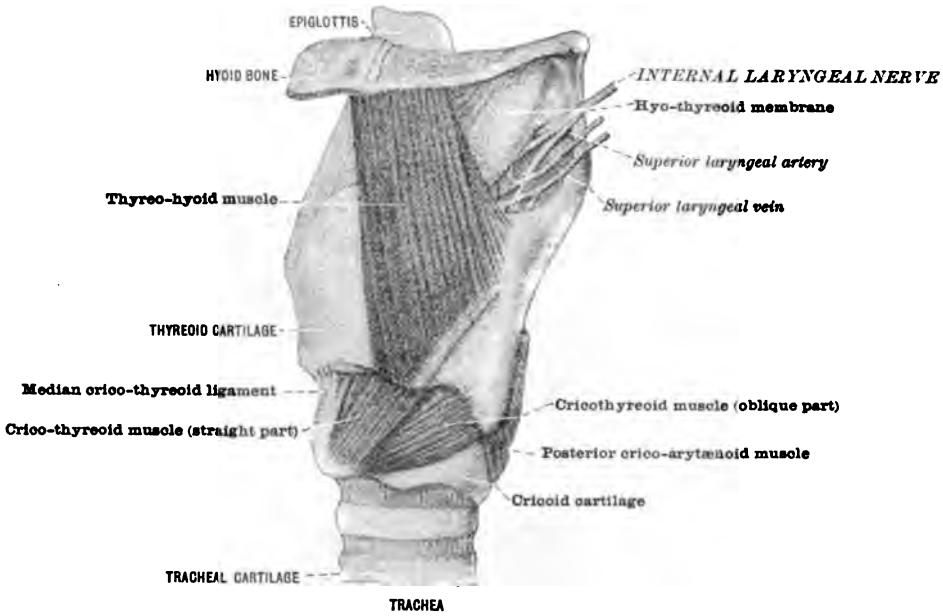
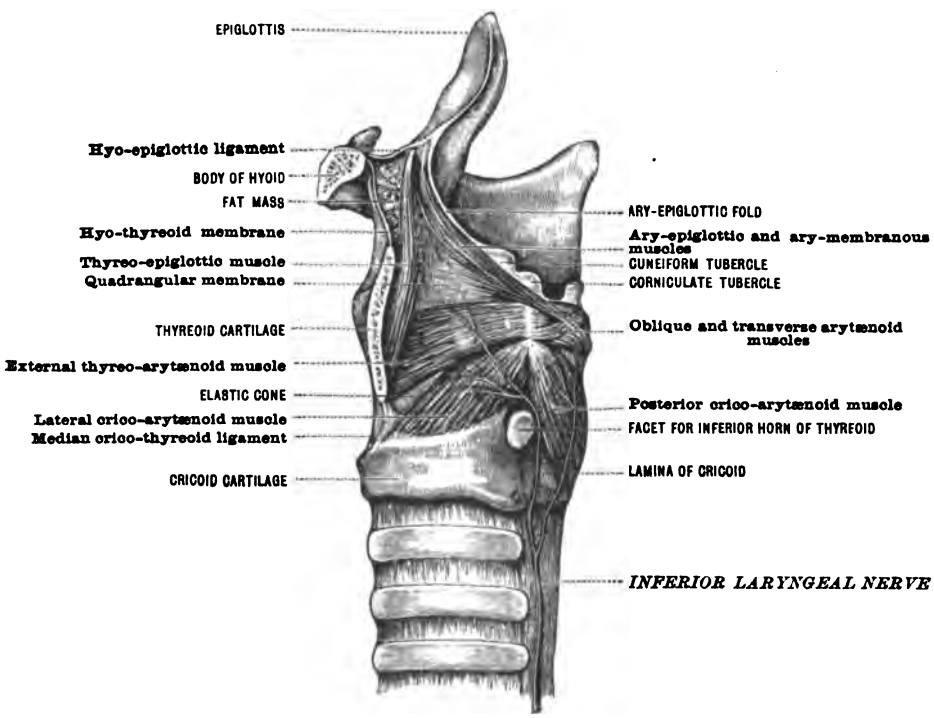


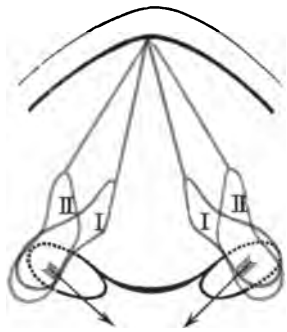
FIG. 832.—THE MUSCLES AND LIGAMENTS OF THE LARYNX SEEN FROM THE SIDE. (The left lamina of the thyreoid cartilage has been removed.)



elastic fibres which stretch as the *lateral hyo-thyreoid ligament* from the superior horn of the thyreoid to the greater horn of the hyoid. A little **cartilago triticea**

is sometimes present in this band. The middle part, *median hyo-thyreoid ligament*, thick and elastic, extends from the superior thyreoid notch to the superior border

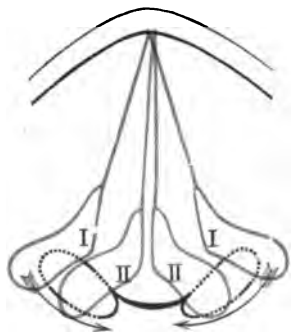
FIG. 833.—SCHEME OF RIMA, SHOWING ACTION OF POSTERIOR CRICO-ARYTÆNOID MUSCLE, WHICH DRAWS THE ARYTÆNOID CARTILAGE FROM I TO II. (Modified from Stirling.)



of the body of the hyoid bone, the *hyoid bursa* being interposed between the latter and the membrane.

The triticeal cartilage is the remains of a connection between the thyreoid and

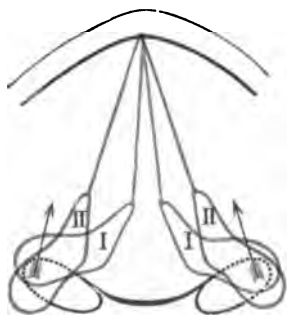
FIG. 834.—SCHEME SHOWING ACTION OF THE TRANSVERSE ARYTÆNOID DRAWING ARYTÆNOID CARTILAGE FROM NEUTRAL POSITION I TO II. (Modified from Stirling.)



hyoid present in the fœtus and persisting in the adult state in some lower animals.

The **hyo-epiglottic ligament** (figs. 828, 832) connects the anterior surface of the

FIG. 835.—SCHEME SHOWING ACTION OF THYREO-ARYTÆNOID DRAWING THE VOCAL PROCESSES AND THE VOCAL LIGAMENTS FROM II TO I. (Modified from Stirling.)



epiglottic cartilage with the superior border of the body and the great horns of the hyoid. It is a broad sheet, lying above a mass of fat which stands between the median hyo-thyreoid membrane and the epiglottis.

Between the root of the tongue and the epiglottis is the elastic **glosso-epiglottic ligament,** contained within the median glosso-epiglottic fold.

The **corniculo-pharyngeal ligament** (fig. 827) extends from the corniculate cartilage downwards and towards the median line, attaching to the mucosa of the pharynx and joining its fellow behind the arytænoid muscle. From this point a single band, the **crico-pharyngeal ligament,** which may enclose a nodule of cartilage (**the interarytænoid cartilage**), descends in the middle line, to be fixed to the cricoid lamina and into the pharyngeal mucosa.

The larynx and trachea are united by fibrous membrane, the *crico-tracheal ligament* (figs. 825, 828), between the inferior border of the cricoid cartilage and the upper margin of the first tracheal ring. Posteriorly the ligament is continued into the membranous wall of the trachea.

MUSCLES OF THE LARYNX

Of the many muscles connected with the larynx, two groups may be recognised, the members of one coming from neighbouring parts, fixing themselves to the larynx, and acting upon the organ as a whole; while the members of the other group are confined exclusively to the larynx and act on certain parts of it.

The extrinsic muscles composing the first group (fig. 830) are described elsewhere. One of them is in connection with the tongue (certain fibres of the genio-glossus), another with the styloid process (stylo-pharyngeus), still others with the axial skeleton (sterno-thyreoid, thyreo-hyoid) and with the pharynx (inferior constrictor, the pharyngo-palatinus). In swallowing, the stylo-pharyngeus, pharyngo-palatinus, and thyreo-hyoid elevate the larynx, and the sterno-thyreoid helps to restore it to its original position; the inferior constrictor compresses the pharynx by drawing its anterior wall (larynx) backwards. The thyreo-hyoid elevates the larynx in the production of a high note; the sterno-thyreoid, with other muscles, depresses it in the utterance of a low note.

The muscles of the second group are composed of striated fibres and are supplied by the vagus nerve through its laryngeal branches. These **intrinsic muscles** are all more or less under cover of the thyreoid cartilage, with one exception, the crico-thyreoid.

The **crico-thyreoid muscles** (figs. 830, 831) are placed one on either side of the outer surface of the larynx in its lower part. Each muscle is partially separated into an anterior straight and a posterior oblique portion, which together arise from the arch of the cricoid. The fibres of the straight part ascend steeply and are inserted into the inferior margin of the thyreoid cartilage. The oblique portion is inserted into the inferior horn and into the lower margin and inner surface of the thyreoid cartilage.

A connection between the posterior part of this muscle and the inferior constrictor of the pharynx and their common nerve-supply indicate their genetic relationship.

The straight part elevates the arch of the cricoid, causing the lamina, and with it the arytænoid cartilages, to sink, while the oblique part draws forwards the thyreoid; thus the vocal ligaments are made tense. The muscle is supplied by the external branch of the superior laryngeal nerve.

The **crico-arytænoideus posterior** (figs. 831, 832, 833), paired, is situated at the back of the larynx, covered by the submucous coat of the pharynx. It is a thick, triangular mass which takes origin from the posterior surface of the cricoid lamina, the two muscles, being well separated by the median crest of the cartilage. The lower fibres ascend and the upper ones pass horizontally outwards and are inserted into the muscular process of the arytænoid cartilage on its posterior surface and tip.

When these muscles contract, the muscular processes of the arytænoids are pulled backwards and downwards, while the vocal processes travel lateralwards and a little upwards, so that the rima glottidis is widened (fig. 833). The innervation is the posterior branch of the inferior laryngeal nerve.

In ether narcosis the dilator muscle is later paralyzed and afterwards earlier restored than the constrictors of the glottis.

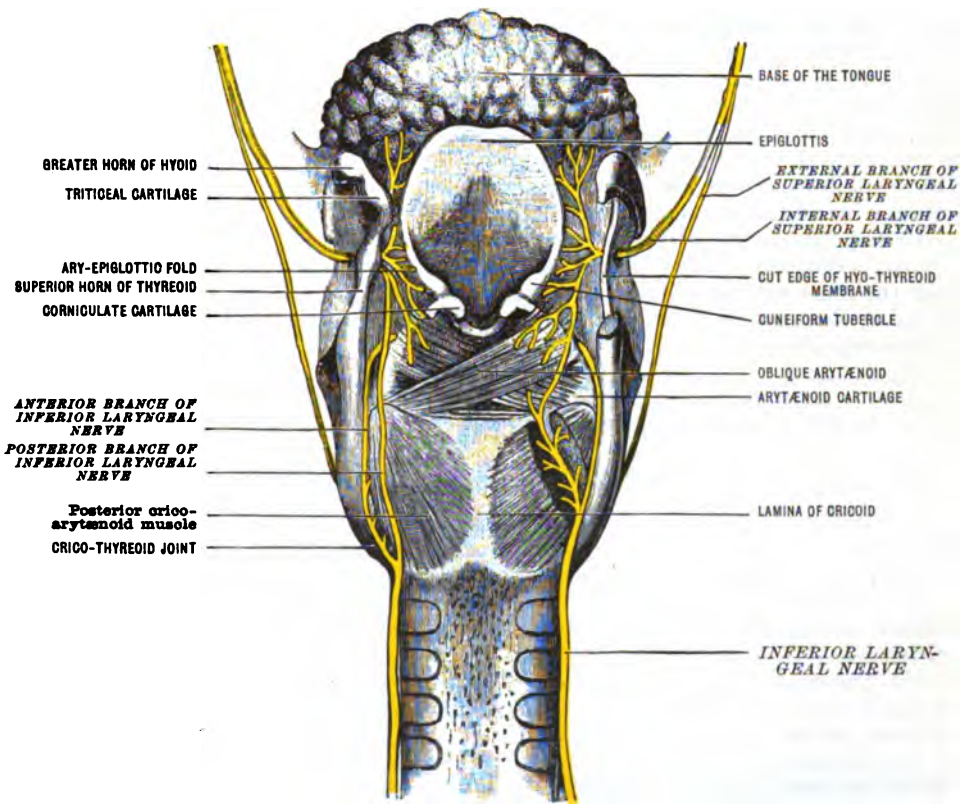
At the lower border of this muscle a little slip, the **cerato-cricoid,** is sometimes found, extending between the lamina of the cricoid and the inferior cornu of the thyreoid cartilage.

The constrictor laryngis.—While the crico-arytænoideus posterior is a dilator of the rima glottidis, the several muscles now to be considered are in the main constrictors. They form a ring, the constrictor laryngis, around the laryngeal cavity, interrupted, however, by the cartilages. In the larynx of amphibia and reptiles a complete sphincter guards the entrance to the air-passages.

The following muscles are included in this group:—

The **arytænoideus transversus** (figs. 832, 834, 836) is a single muscle of quadrilateral form, extending across the middle line from the posterior concave surface of one arytænoid cartilage to that of the other. Its anterior surface, between the cartilages, is covered by the laryngeal mucosa, while its posterior surface, crossed by the arytænoideus obliquus, is clothed by the submucous coat of the pharynx. The arytænoideus transversus approximates the arytænoid cartilages and their vocal processes, which are at the same time elevated, and the vocal ligaments made tense. Its nerve is the posterior branch of the inferior laryngeal.

FIG. 836.—THE NERVES OF THE LARYNX SEEN FROM BEHIND.



The **crico-arytænoideus lateralis** (fig. 832) arises from the upper border and outer surface of the cricoid arch and elastic cone, whence the fibres extend backwards and upwards to an insertion on the anterior surface of the muscular process of the arytænoid cartilage. This muscle is inseparable from the thyreo-arytænoideus in about half the cases.

Through their contraction the vocal processes move towards the median line and a little downwards, so that the vocal ligaments are approximated and slightly stretched. They antagonise the posterior crico-arytænoids. The anterior branch of the inferior laryngeal nerve supplies each muscle.

The **thyreo-arytænoideus (externus)** (figs. 832, 835, 838), variable in form and in the disposition of its fibres, is closely connected with the preceding. It lies under cover of the thyreoid lamina and external to the laryngeal saccule (ventricular appendix) and elastic cone. Arising within the angle of the thyreoid laminæ the muscle extends upwards and backwards to its insertion on the external border

of the arytænoid cartilage. It draws forwards the arytænoid cartilage (and also tilts the cricoid), and rotates it so that the vocal process passes inwards and downwards, relaxing the vocal ligament. It is the antagonist of the crico-thyreoid (fig. 835). Its nerve-supply is the anterior branch of the inferior laryngeal.

The **thyreo-arytænoideus internus (m. vocalis)** (fig. 838), prismatic in form, is the inner constant part of the thyreo-arytænoideus. It lies in the vocal lip lateral to the vocal ligament. Its fibres run from their origin in the angle of the thyreoid laminæ to their insertion in the vocal process and oblong fovea of the arytænoid cartilage. It draws forwards the vocal process, relaxing the vocal ligament. The nerve comes from the anterior branch of the inferior laryngeal.

The insertion of certain fibres of this muscle into the elastic vocal ligament is supported by some observations (ary-vocalis muscle of Ludwig). D. Lewis has shown that some of the elastic fibres in the vocal ligament are derived from the perimysium of the vocal muscle.

The *ventricular* muscle consists of a few fibres derived from the thyreo-arytænoideus which reach the back of the laryngeal saccule and enter the ventricular fold. The little *thyreo-arytænoideus superior* extends from the angle of the thyreoid to the muscular process of the arytænoid upon the lateral surface of the main muscle.

The **arytænoideus obliquus** is a slender band lying at the back of the larynx and under the pharyngeal submucosa. It arises from the muscular process of the arytænoid posteriorly, and, ascending obliquely, crosses its fellow in the median line and is in part inserted into the apex of the opposite arytænoid cartilage. Some fibres sweep around the apex and accompany the thyreo-arytænoid to an insertion in the angle of the thyreoid cartilage, constituting the *thyreo-arytænoideus obliquus*. This muscle contracts the entrance and vestibule of the larynx. Its nerve is the anterior branch of the inferior laryngeal.

Closely connected with the thyreo-arytænoideus is a bundle of fibres of fairly regular occurrence, called the **thyreo-epiglottic muscle** (fig. 832). It originates from the inner surface of the thyreoid lamina and proceeds upwards and backwards to end in the quadrangular membrane and to become attached to the lateral border of the epiglottis.

The *ary-membranosus* and *ary-epiglottic muscles* are inconstant fascicles of the constrictor group which run in the ary-epiglottic fold and become fixed into the quadrangular membrane and border of the epiglottic cartilage.

Review of Some of the Actions of the Intrinsic Laryngeal Muscles

According to their actions, the intrinsic muscles may be divided into—(*a*) those which effect the tension of the vocal folds; (*b*) those which control the rima glottidis; (*c*) those which effect the closure of the entrance and vestibule.

(*a*) The vocal ligaments are made tense by the action of the crico-thyreoid muscles and allowed to relax through the action of their antagonists, the thyreo-arytænoids.

(*b*) The rima glottidis is widened by the crico-arytænoideus posterior and closed by the arytænoidei. The crico-arytænoideus lateralis also closes the rima glottidis by rotating the vocal processes inwards.

(*c*) The entrance and vestibule are closed mainly by the arytænoideus transversus and thyreo-arytænoideus (externus), by which the arytænoid cartilages are brought into apposition and drawn towards the epiglottis. Other muscles derived from the constrictor group, arytænoideus obliquus and ary-epiglottic, assist in closing the entrance. The epiglottis stands erect and does not fall as a lid over the vestibule, according to Anderson Stuart.

CAVITY OF THE LARYNX AND LARYNGEAL MUCOSA

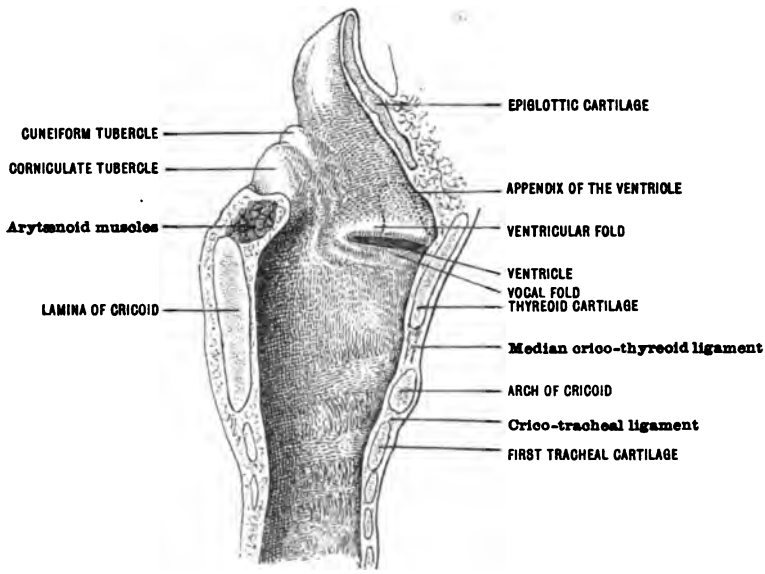
The lumen of the larynx is relatively narrow and does not correspond in shape with the outer surface of the organ. Its walls are covered throughout by a mucous membrane (figs. 837, 838).

The cavity above the level of the vocal folds is known as the **vestibule.** This is wide in its upper part, but the sides incline towards the median line in descending, and the cavity is in consequence narrow transversely in the region of the vocal folds. The anterior wall is much higher than the posterior. The walls of the vestibule are composed in front by the epiglottic and thyreoid cartilages with the thyreo-epiglottic

ligament; at the side, by the quadrangular membrane, the cuneiform and corniculate cartilages, and the medial surface of the arytænoid cartilage; behind, by the anterior surface of the transverse arytænoid muscle. The vestibule communicates with the pharynx by the **superior aperture (aditus)** (figs. 821, 822, 823, 837), which looks upwards and backwards. The form of the aperture is oval or triangular, with the base in front; here it is bounded by the epiglottis; laterally by the ary-epiglottic fold of the mucosa. Posteriorly the entrance is prolonged as a little notch between the tips of the arytænoids, and limited by a commissure of the mucosa.

The mucosa of the vestibule is continuous with that of the pharynx (figs. 821, 822, 837, 838). At the root of the tongue it is reflected backwards to the anterior surface of the epiglottis, presenting the *median* and *lateral glosso-epiglottic folds*. From the pharynx it passes medialwards, sinking between the thyreoid cartilage laterally and the arytænoid and cricoid medially, making the piriform sinus; then over the superior margin of the quadrangular membrane as the **ary-epiglottic fold.** The latter extends from the side of the epiglottis to the apex of the arytænoid cartilage, and within it are fibres of the ary-epiglottic and thyreo-epiglottic muscles and the cuneiform and corniculate cartilages. These cartilages correspond to two rounded eminences on each side of the laryngeal entrance, the **cuneiform** and **corniculate tubercles** respectively. Another elevation, seen on the anterior wall, is known as the **tubercle of the epiglottis.**

FIG. 837.—MEDIAN SECTION OF THE LARYNX. (Merkel.)



On either side of the vestibule, towards its inferior end, is the sagittally running **ventricular fold (false vocal cord)** (figs. 821, 822, 837, 838). Each ventricular fold overhangs a deep groove, the **ventricle** of the larynx (*ventricle of Morgagni*), which is limited in part below by another fold, the **true vocal cord** or **vocal fold** (fig. 838). The ventricular fold contains the inferior free edge of the quadrangular membrane, as the ventricular ligament, and numerous glands.

Wylie's experiments with the ventricular folds, which have since been confirmed by Brunton and Cash, led him to conclude that the closure of the glottis in defæcation and vomiting is mainly effected by the apposition of these folds. (Quain.)

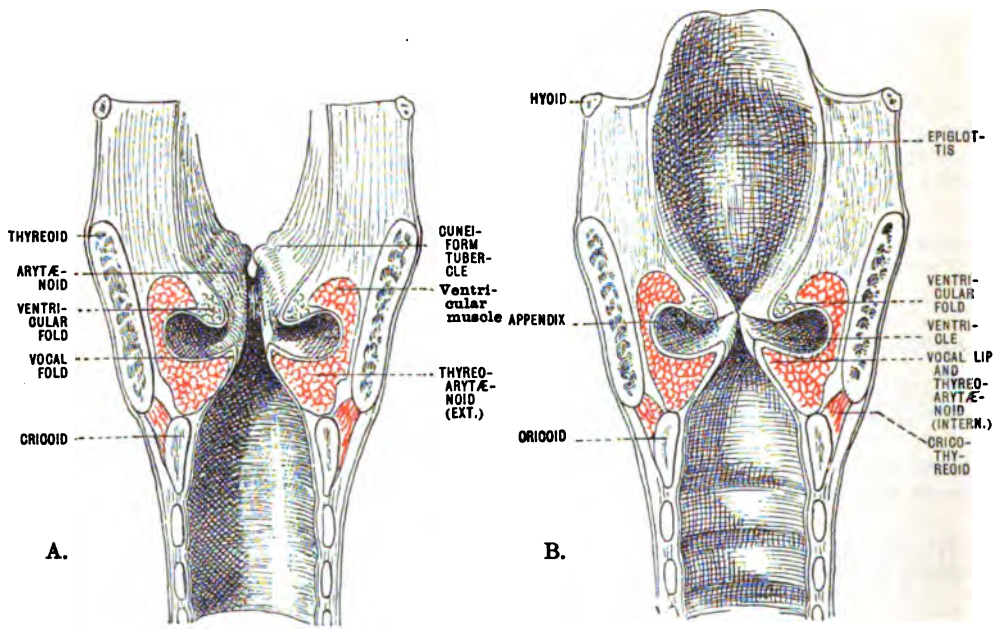
The interval between the ventricular (false vocal) folds leads to a space between the planes of false and true vocal cords, which extends on each side into the laryngeal ventricle (figs. 821, 822, 837, 838). The latter is a little antero-posterior pocket reaching from the level of the arytænoid nearly to the angle of the thyreoid cartilage, and undermining the ventricular fold. From its anterior part a small diverticulum, the **ventricular appendix** or **laryngeal saccule,** extends upwards between the ventricular fold medially and the thyreo-arytænoid muscle and thyreoid cartilage laterally. Many mucous glands open into it.

The appendix is occasionally so large as to reach the level of the upper margin of the thyreoid cartilage or even to the great horn of the hyoid bone. The laryngeal pouches of the higher apes are remarkably developed.

The **vocal fold (true vocal cord)** (figs. 821, 822, 837, 838) is the thin edge of a full, lip-like projection, which forms the floor of the ventricle. The **vocal lip** contains the upper part of the elastic cone, whose thickened free edge, the **vocal ligament,** lies in the vocal fold and along the vocal muscle. The vocal folds correspond in extent to the vocal ligaments, and stand nearer the median line than the ventricular folds. In colour they are pearly white, excepting at the anterior end of each, where there is a **yellow spot,** produced by a little mass of elastic tissue (sometimes cartilage) in the ligament. The two vocal lips and the intervening space together constitute the vocal apparatus or **glottis.**

Between the vocal folds and the medial surfaces of the arytænoid cartilages is a slit, the **rima glottidis** (figs. 821, 822, 838), the narrowest part of the laryngeal cavity, which extends from the arytænoideus transversus muscle posteriorly to the thyreoid cartilage in front. The portion of the rima between the vocal folds is the **pars intermembranacea;** that between the arytænoids, the **pars intercartilaginea.** The rima glottidis in easy respiration has the form of a long triangle; when widely opened it is lozenge-shaped.

FIG. 838.—FRONTAL SECTION OF A LARYNX HARDENED IN ALCOHOL. A. Posterior segment. B. Anterior segment. (Poirier and Charpy.)



Its length in the quiescent state is on the average 23 mm. in the male; 17 mm. in the female. In the male the pars intermembranacea measures 15·5 mm., the pars intercartilaginea 7·5 mm. In the female these are 11·5 mm. and 5·5 mm. respectively. The rima may be lengthened by stretching of the vocal folds to 27·5 mm. in the male and 20 mm. in the female. (Moura.)

In the male the rima glottidis is 6–8 mm. in its widest part, but may be increased nearly to 12 mm.

Below the level of the vocal folds is the space called the **inferior aperture of the glottis** (fig. 838), which is narrow from side to side above, wide and circular in section below—altogether somewhat funnel-shaped. Its walls are formed by the elastic cone and by the arch and lamina of the cricoid cartilage. The lining mucosa is separated from the elastic cone by numerous glands and loose connective tissue, a condition favorable to the development of œdema; below it is continuous with the mucosa of the trachea.

The attachment of the mucosa to the underlying parts is very firm in certain regions, as about the vocal folds and dorsal side of the epiglottis, and loose in the ary-epiglottic folds, where much areolar tissue is present. In general the mucosa is thin and pale, and this is especially the case over the vocal folds, which appear

almost white. Numerous **mucous glands** occur about the larynx and are aggregated into groups in certain places. One cluster, that of the *anterior glands*, is upon the epiglottis; another, that of the *middle glands*, is in the ventricular fold, in the triangular fovea of the arytænoid cartilage and clustered about the cuneiform cartilage, while a third set, the *posterior glands*, is disposed about the transverse arytænoid muscle. Many glands pour their secretion into the laryngeal saccule, but there are none on or about the vocal folds. **Lymph-nodules** occur in the mucosa of the ventricle and on the posterior surface of the epiglottis.

Peculiarities of age and sex.—Position.—The larynx is relatively higher in the neck in fœtal and infantile life than at the age of puberty, when it has descended to the position which it continues to hold throughout life. In a six-months fœtus the organ is two vertebræ higher than in the adult. (Symington.) The descent has been attributed to the vertical growth of the facial part of the skull, but this cause is questioned by Cunningham, who points out the high position of the larynx in the anthropoid apes, where the facial growth is more striking than in man; he shows also that the larynx follows the thoracic viscera in their subsidence during early stages. The larynx continues to grow until the third year, when a resting period begins, lasting until twelve years of age, during which time there is no difference between the larynx of the male and female. Rapid growth begins at puberty in the male, at which time the voice changes. The thyreoid cartilage undergoes the greatest changes and causes the prominence at the front of the neck of the male. The final proportions are attained at twenty to twenty-five years.

Dimensions.—In the male the distance from the upper edge of the epiglottis to the lower border of the cricoid is 70 mm.; in the female, 50 mm. The transverse diameter is 40 mm. in the male, 35 mm. in the female. The sagittal diameter from the inferior border of the thyreoid to the cricoid lamina is 30 mm. in the male, 25 mm. in the female. To the size of the thyreoid is due the greater length of the vocal folds in the male, where they measure about 15 mm., those in the female measuring but 11 mm. Castration interferes with the development of the larynx, and in the eunuch it has been found to be of the size of that of a young woman. The changes in the structure of the cartilages have already been described.

Vessels and nerves (figs. 831, 836).—The *arteries* supplying the larynx are the superior and inferior laryngeal, which accompany the internal and inferior laryngeal nerves respectively. Another source of blood-supply is the crico-thyreoid artery. The superior laryngeal passes through the hyo-thyreoid membrane, and after giving twigs to the epiglottis, descends under the mucosa to the lower border of the thyreoid lamina, where it divides into two terminal branches which anastomose with the inferior laryngeal and crico-thyreoid arteries. The latter artery runs downwards and inwards on the thyreo-hyoid muscle to reach the inferior border of the thyreoid cartilage, where it divides into two branches. One of these anastomoses with its fellow across the middle line, and sends branches through the median crico-thyreoid ligament to the lower division of the larynx; the other terminal branch anastomoses with the superior laryngeal. The inferior laryngeal artery enters the larynx with the nerve of the same name behind the crico-thyreoid articulation. It divides into two branches, one of which supplies the crico-arytænoideus posterior; the other anastomoses with the superior laryngeal artery.

The finer branches present no special features, but it is to be noted that the vascular supply of the true vocal cords is relatively poor, a fact which probably accounts for their paleness. The *veins* are the superior, middle, and inferior thyreoid.

The *lymph* vascular system is well developed throughout the larynx generally, but in the vocal folds where the mucosa is thin and tightly bound down the vessels are scarce and small in size. Two superior trunks drain the region above the glottis towards a lymph-node outside the hyo-thyreoid membrane, and to one under the sterno-mastoid muscle, near the bifurcation of the common carotid artery. Two inferior trunks come from the region below the glottis and empty into nodes placed one on either side of the membranous wall of the trachea. A small node sometimes found in front of the median crico-thyreoid ligament may receive the lymph from the lower part of the larynx. (Poirier.)

The *nerves* of the larynx are the superior and inferior laryngeal branches of the vagus and also certain branches of the sympathetic. The innervation of the muscles has already been given, and the description of the course and relations of these nerves will be found in the chapter on the PERIPHERAL NERVOUS SYSTEM. The innervation of the mucosa is through the internal branch of the superior laryngeal, the finer ramifications forming subepithelial plexuses with end fibres between the cells. Taste-buds occur and are abundant in the mucosa of the posterior surface of the epiglottis.

It should be mentioned here, however, that the idea of sharply limited territories of innervation, not only for the mucosa, but for the muscles as well, has been brought into question by recent researches (Semon and Horsley, Exner, and others), which show that the distribution and functions of the laryngeal nerves are extremely complex.

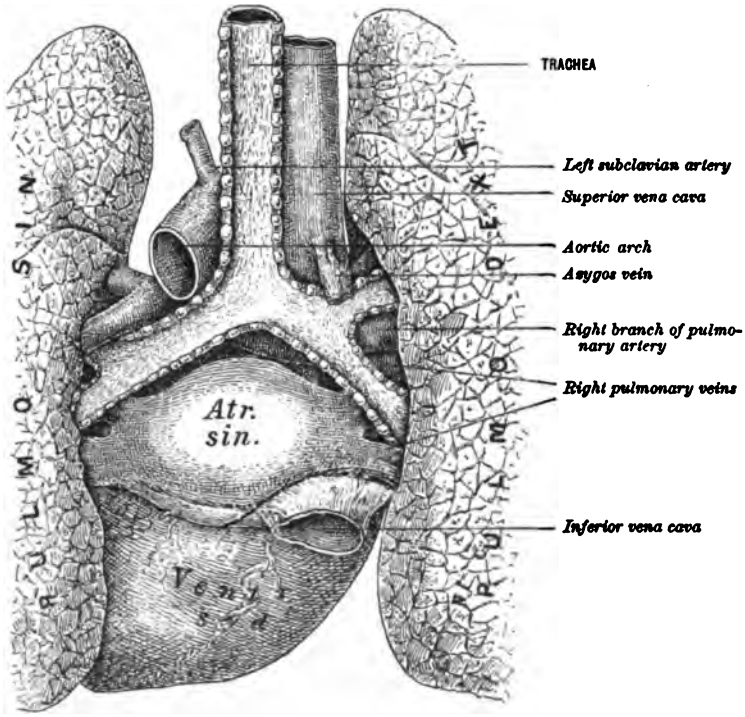
The development of the larynx.—The larynx is developed partly from the lower portion of the embryonic pharynx and partly from the upper portion of the trachea. The cricoid cartilage represents the uppermost tracheal cartilage, while the thyreoid is formed by the fusion of four

cartilages representing the ventral portions of the cartilages of the fourth and fifth branchial arches. The laryngeal muscles are derived from the musculature of these arches and consequently their nerve-supply is from the vagus (see p. 9). Whether or not the arytænoid and epiglottic cartilages are also derivatives of the branchial arches is uncertain, although it seems probable that they are.

THE TRACHEA AND BRONCHI

The tubular **trachea** (figs. 823, 830, 839), or windpipe, extends from the larynx downwards through the neck and into the thorax to end by dividing into two branches, the **right** and **left bronchi,** which lead to the lungs. These tubes are simple transmitters of the respiratory air. The walls of the trachea and bronchi are, for the most part, stiff and elastic, and in form are convex at the sides and in front; posteriorly, however, the wall is flaccid, and in the trachea its contour is more or less adapted to the œsophagus, against which it rests. Sections of the trachea show that it is not perfectly symmetrical bilaterally, and Lejars points out that the roundness of its surfaces suffers further by the encroachments of the aortic arch

FIG. 839.—TRACHEA AND BRONCHI IN THEIR RELATIONS TO THE GREAT VESSELS AS SEEN FROM BEHIND. (After Gegenbaur.)



and the thyreoid gland. The lumen of the tubes is a little irregular through a succession of slight annular projections caused by the cartilaginous rings which enter into their walls. The calibre of the trachea varies at different levels, being in general spindle-shaped. Its sectional area is less than the combined areas of the two bronchi. When the bifurcation is viewed by looking down into its cavity, a sagittally directed keel, the **carina tracheæ** (fig. 840), is seen standing between the openings which lead into the bronchi. Its position is a little to the left in a slight majority of cases, or in the middle line in a large percentage.

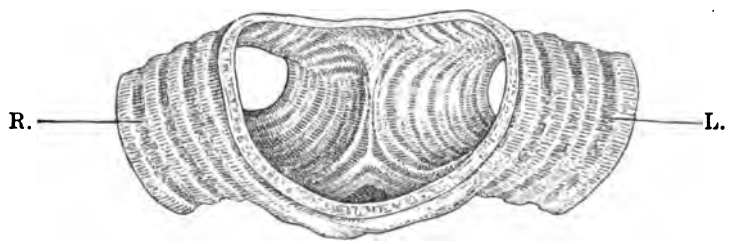
Position and relations (figs. 823, 830, 839, 849).—The trachea lies in the middle line, extending from the level of the seventh cervical vertebra downwards and backwards, receding from the surface in following the curve of the vertebral column, and deviating a little to the right in approaching the fourth thoracic vertebra, where it divides. Its lower end is fixed so that with elevation and descent of the larynx the tube is stretched and contracted, changes in length which also result from movements of the head and neck. The mobility of the trachea is favored by its loose investment of connective tissue.

Somewhat less than half of the trachea lies in the neck, but the extent varies with the length of the neck and the position of the head. In front and closely connected with it is the isthmus of the thyreoid gland, covering usually the second to fourth cartilages; anterior to this the cervical fascia and integuments. The cervical aponeurosis is attached to the upper border of the sternum in two lamellæ, with an interspace containing the jugular arch, a lymph node, and some fat. Between these aponeuroses and the trachea is another space containing the inferior thyreoid veins and some pretracheal lymph-nodes, and sometimes a thyreoidea ima artery. The innominate artery occasionally crosses the trachea obliquely in the root of the neck. Behind the trachea, in its whole length, lies the œsophagus, which in this part of its course inclines to the left. On either side are the great vessels and nerves of the neck; the inferior laryngeal nerve in the angle between the œsophagus and trachea; and the lobes of the thyreoid gland.

Within the thorax the trachea lies in the mediastinum, enveloped in loose areolar tissue and fixed through strong fibrous connections with the central tendon of the diaphragm. The innominate artery and the left common carotid are in front, and then at its sides as they ascend, while the left innominate vein and the remains of the thymus are further forwards. The aortic arch is in contact anteriorly near the bifurcation; also the cardiac plexus. On the right side are the vagus nerve, the arch of the vena azygos (major), the superior vena cava, and the mediastinal pleura; on the left, the arch of the aorta, the left subclavian artery, and the recurrent laryngeal nerve. A large group of lymph-nodes lies below the angle of bifurcation. The œsophagus is behind and to the left.

The **bronchi** take an oblique course to the hilus of the lung, where they branch. The right bronchus is nearer to the vertical in its course than the left, and it is also

FIG. 840.—BIFURCATION OF THE TRACHEA SHOWING THE TRACHEAL KEEL. R. L. Right and left bronchi. (Heller and von Schroetter, from Poirier and Charpy.)



shorter and broader. These conditions, together with the position of the tracheal keel, explain the more frequent entrance of foreign bodies into the right than into the left bronchus. The asymmetrical course of the two bronchi is doubtless genetically connected with the position of the heart and aorta, as Merkel suggests. The azygos vein arches over the right bronchus, the vagus passes behind, and the right branch of the pulmonary artery crosses anteriorly below the level of the first (eparterial) branch of the bronchus. The aorta arches over the left bronchus and gains its posterior aspect along with the œsophagus; the left branch of the pulmonary artery passes at first in front and then above it.

Dimensions.—On account of their elasticity considerable difficulty is met with in obtaining accurate measurements of the air-tubes. The length of the trachea is 95–122 mm.; its transverse diameter 20–27 mm.; the sagittal diameter 16–20 mm. (Krause.) The right bronchus has a length of 25–34 mm.; the left, 41–47 mm. The transverse diameter of the right is 18 mm.; of the left, 16 mm. (Krause.) The angle of bifurcation of the trachea varies from 56° to 90° (Aeby), the mean being 70.4°, a wide angle and in correspondence with the broad thorax of man. The right bronchus makes with the median plane an angle of 24.8°; the left, 45.6°.

According to Tillaux that portion of the trachea between the superior edge of the sternum and the cricoid cartilage has the following lengths:—

Adult male,	from 4·5	to 8·5 cm.	average,	6·5 cm.
Adult female,	" 5	to 7·5 cm.	"	6·4 cm.
Boys 2½ to 10 years,	" 2·7	to 6·5 cm.	"	4·4 cm.
Girls 3½ to 10½ "	" 4	to 6·5 cm.	"	5·1 cm.

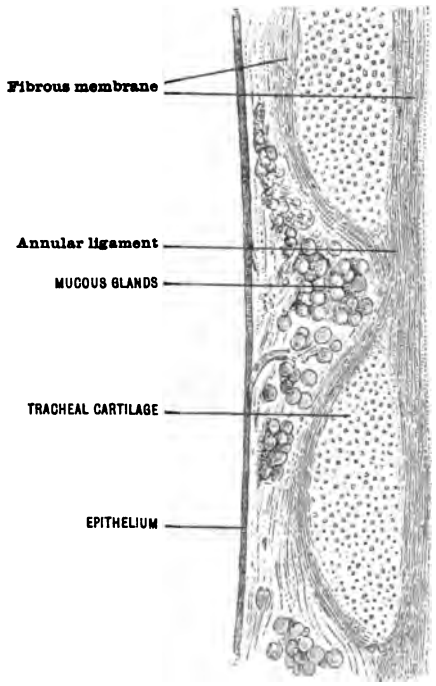
The diameter of the trachea when the lumen is distended to a cylindrical form has been measured by Sée:—

New-born	4·12 to 5·6 mm.
Infant 2 years	7·5 to 8 mm.
Infant 4 to 7	8 to 10·5 mm.
Over 20 years, male	16 to 22·5 mm.
Over 20 years, female	13 to 16 mm.

Structure of the trachea and bronchi (figs. 828, 838, 839, 841).—The walls of the trachea and bronchi are composed of a series of cartilages having the form of incomplete rings, held together and enclosed by a strong and elastic fibrous membrane. Posteriorly, where the rings are deficient, this membrane remains as a lax wall; between the cartilages it constitutes the **annular ligaments.**

A **tracheal cartilage** comprises a little more than two-thirds of a circle. Its ends are rounded, its outer surface is flat, while the inner surface is convex from above downwards; its upper and lower margins are nearly parallel. The cartilages are from sixteen to twenty in number. The first is usually broader than the type, and is connected by the crico-tracheal ligament with the cricoid cartilage. Sometimes these two cartilages are in part continuous. The last ring is adapted to the bifurcation, and presents a hook-like process of the middle of its lower margin, which

FIG. 841.—SCHEMATIC LONGITUDINAL SECTION OF THE WALL OF THE TRACHEA. (Gegenbaur.)



turns backwards between the origins of the bronchi, and in the majority of cases gives a cartilaginous basis to the tracheal carina. Some of the tracheal cartilages vary from the type by bifurcating at one end. The cartilages keep the lumen of the trachea patent for the free passage of the air. Calcification occurs as with the laryngeal cartilages, but much later in life.

A mucous membrane, soft and pinkish-white in colour, covers the inner surface of the trachea; posteriorly it is thrown into longitudinal folds. A thin layer of transversely disposed smooth muscle-fibres stretches between the ends of the cartilages in the posterior wall, and mucous **tracheal glands** are present in the elastic submucous coat, more numerous in front and at the back of the trachea.

The structure of the walls of the bronchi is similar to that of the trachea. The right bronchus possesses six to eight cartilages; the left, nine to twelve. A little *broncho-œsophageal* muscle connects the back of the left bronchus with the gullet.

Vessels and nerves.—The *arteries* supplying these air-tubes come from the inferior thyreoid

and from the internal mammary by its anterior mediastinal branches. These vessels reach the trachea and bronchi by a few anterior and several posterior branches, the former building anastomotic arches in the annular ligaments, the latter ramifying in the membranous wall. *Venous radicles* come together in the annular ligaments and join lateral veins on either side, which empty the blood into the plexuses of the neighbouring thyreoid veins.

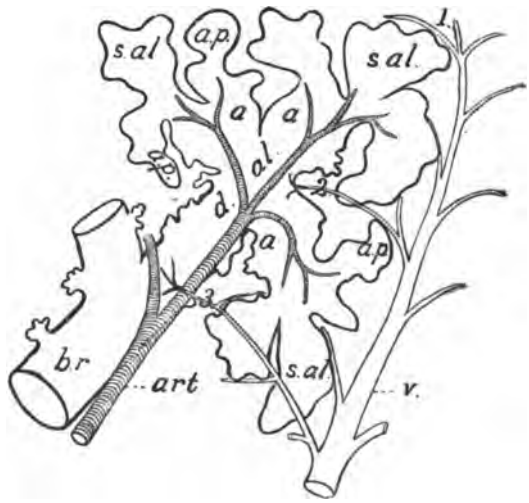
Lymph-vessels are abundant, and are, according to Teichmann, disposed in two sets, one in the mucosa, another in the submucosa. They drain into the tracheal and œsophageal lymph-nodes. *Nerves* are provided by the vagus direct, by the inferior laryngeal, and by the sympathetic.

THE LUNGS

The **lungs (pulmones)**, as the special organs of respiration, are constructed in such a way as to allow the blood to come into close relation with the air (fig. 842). Their genetic connection with the entodermal canal has already been indicated (see also p. 1156). In plan of structure the lung has been compared to a gland, since it is composed of a tree-like system of tubes which end in enlargements. Closely associated with the system of tubes are certain blood-vessels, some of which take part in nourishing the organ, and others participate in its special mechanism.

FIG. 842.—SCHEMATIC SECTION OF A LOBULE OF THE LUNG SHOWING THE RELATION OF THE BLOOD-VESSELS TO THE AIR-SPACES. (After Miller, from the "Reference Handbook of the Medical Sciences.")

b.r. Respiratory bronchiole. *d.al.* Alveolar duct; a second alveolar duct is shown cut off. *a, a.* Atria. *s.al.* Alveolar saccule. *a.p.* Alveolus. *art.* Pulmonary artery with its branches to the atria and saccules. *v.* Pulmonary vein with its tributaries from the pleura (1), the alveolar duct (2), and the place where the respiratory bronchiole divides into the two alveolar ducts (3).



The lungs are two in number, and lie one on either side of the thoracic cavity, separated by a partition made up by the heart and great vessels, the trachea and œsophagus, and known as the **mediastinum** (figs. 843, 847, 849). Serous membranes covering the latter right and left are parts of two closed sacs, the **pleuræ**, each one of which is reflected about a lung and the neighbouring chest-wall after the manner of serous membranes in general. The space enclosed within the sac-walls is a subdivision of the cœlom.

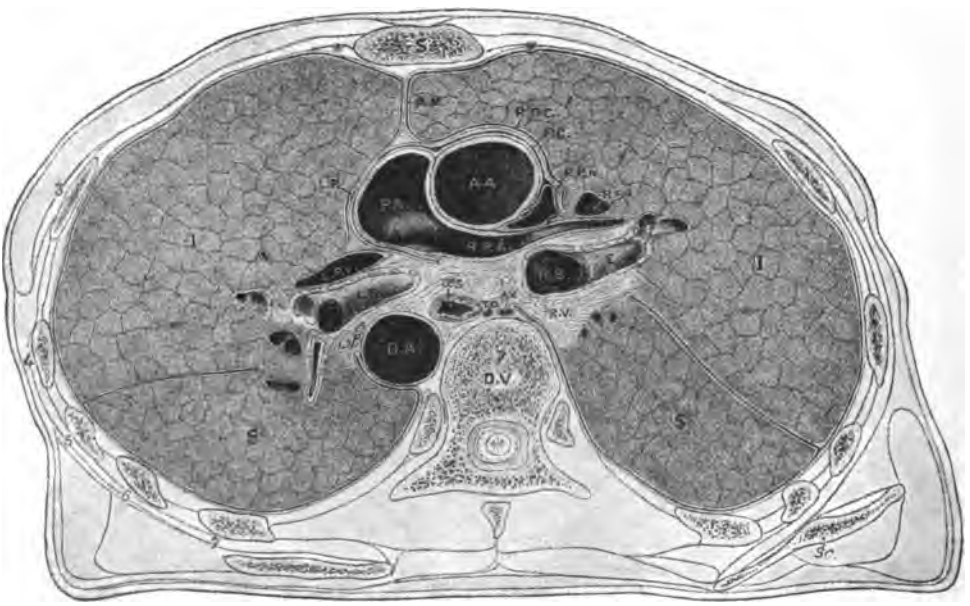
Form (figs. 844, 848).—The lung is pyramidal or conical in form, with the **base** below and resting on the diaphragm, and with the **apex** above, in the root of the neck. A broad convex **lateral or costal surface** is directed against the thoracic wall in front, laterally and behind, and is marked by grooves corresponding to the ribs. A **medial or mediastinal surface** is concave and adapted to the convexity of the mediastinum (fig. 844). A special concavity on this surface, the **cardiac fossa**, corresponds to the prominence of the heart, and is deeper on the left lung than on the right. Above and behind the cardiac fossa is a depression, the **hilus** of the lung, where the bronchus and pulmonary vessels and nerves together consti-

tuting the **root** of the organ, enter and leave. Near the posterior edge of the mediastinal surface is a groove, which ascends and turns forwards over the hilus; on the left lung, it fits the aorta; on the right, the vena azygos. A well-marked sulcus extends upwards on this surface to the apex, corresponding on the right side to the lower part of the trachea and right subclavian artery, on the left to the left artery alone. Further forwards is a groove adapted in the right lung to the superior cava; in the left to the left innominate vein. The lung is not in actual contact with these several structures, but is separated from them by the mediastinal pleura.

The mediastinal surface passes gradually into the costal surface posteriorly, there being no proper posterior edge. Where the medial and lateral surfaces meet in front, a sharp **anterior margin** exists (fig. 847). In the right lung this runs down in a gentle curve to turn outwards in the inferior margin. In the left lung the anterior margin is cut by a wide **cardiac notch,** which is occupied by the heart in the pericardium as it is pressed towards the anterior chest-wall. The cardiac notch is separated from the inferior margin by a little tongue of lung substance, the **lingula.**

FIG. 843.—HORIZONTAL SECTION OF THE THORAX OF A MAN, AGED FIFTY-SEVEN, AT THE LEVEL OF THE ROOTS OF THE LUNGS, SEEN FROM ABOVE. (J. S.) (Quain.) × ½.

A. A. Ascending aorta. A. M. Anterior mediastinum. A. V. Azygos vein. D. A. Descending aorta. E. Eparterial bronchus. I. Superior lobe of lung. L. B. Left bronchus. L. P. Left phrenic. L. P. V. Left pulmonary vein. L. V. Left vagus. Œs. Œsophagus. P. A. Pulmonary artery. P. C. Pericardial cavity. R. B. Right bronchus. R. P. A. Right branch of pulmonary artery. R. P. C. Right pleural cavity. R. P. N. Right phrenic. R. P. V. Right pulmonary vein. R. V. Right vagus. S. Inferior lobe of lung. Sc. Scapula. T. D. Thoracic duct. 3, 4, 5, 6, 7. Corresponding ribs.



The **base** of the lung (fig. 844) is concave and oblique in adaptation to the dome of the diaphragm. It is limited by a sharp **inferior margin,** which follows the curves of the medial and lateral surfaces, and fits into the angle between the diaphragm and thoracic wall.

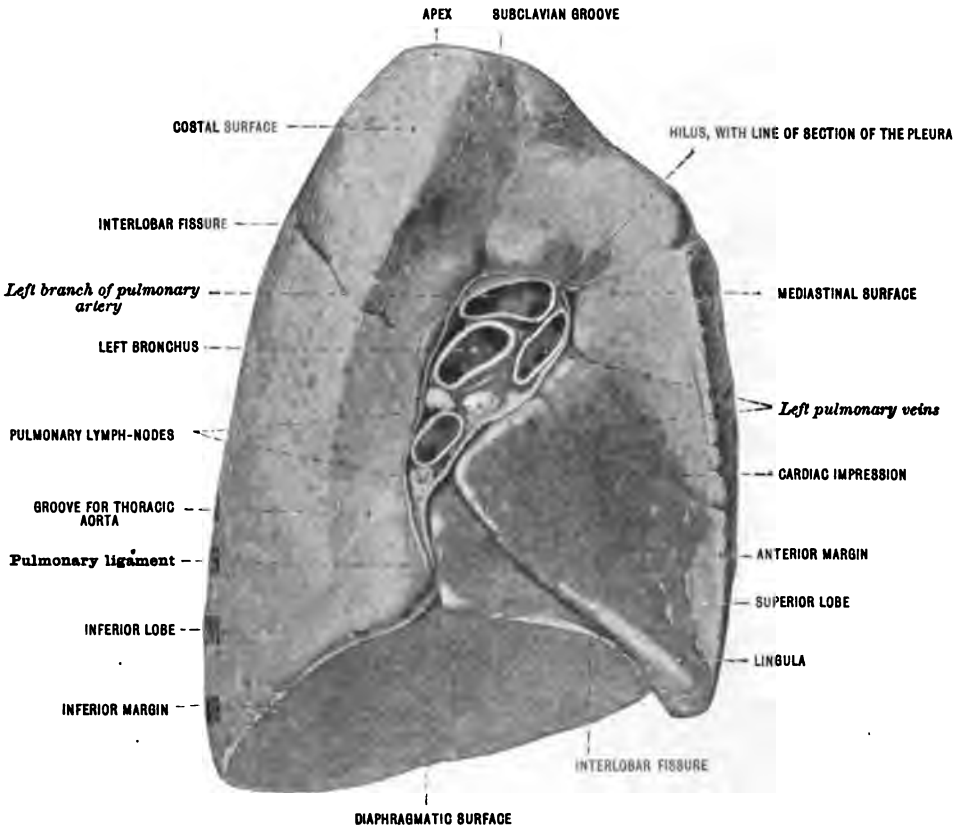
The **apex** (figs. 844, 847, 848) is rounded and points upwards with an inclination forwards and inwards, accommodating itself to the structures within and about the superior aperture of the thorax. In adaptation to the shape of the thoracic cavity, following mainly the asymmetry of the vault of the diaphragm, and to the position of the heart, certain differences in the form of the two lungs present themselves, the right lung being a little shorter and broader than the left.

A deep **interlobar fissure** (figs. 844, 848), reaching through the lung substance nearly to the hilus, divides each organ into a smaller **superior lobe** and a larger **inferior lobe.** The interlobar fissure runs downwards and forwards beginning a short distance below the apex, and reaching the base near the anterior border in the left

lung, but further back in the right lung. From the obliquity of the plane of the fissure it will be noticed that the inferior lobe reaches posteriorly to within a short distance of the apex, and includes the greater part of the back and base of the lung, while the superior lobe takes in the anterior border and apex. The presence of a **middle lobe** disturbs the symmetry of the right lung. This results from a deep, nearly horizontal fissure cutting through the lung somewhat below its middle, and extending between the anterior margin and the main interlobar fissure, which it reaches at about the level of the mid-axillary line.

The **hilus** (fig. 844), already mentioned as situated on the mediastinal surface, presents in the left lung a raquette-shaped outline. Its average height is about 8·8 cm. (Luschka), and it extends over both lobes. The hilus of the right lung, rather four-sided in outline and shorter than the left, is related to the three lobes. The entering structures, constituting the **root** of the lung (figs. 839, 843, 844), include

FIG. 844.—LEFT LUNG, VIEWED FROM THE MEDIAL SURFACE. (Spalteholz.)



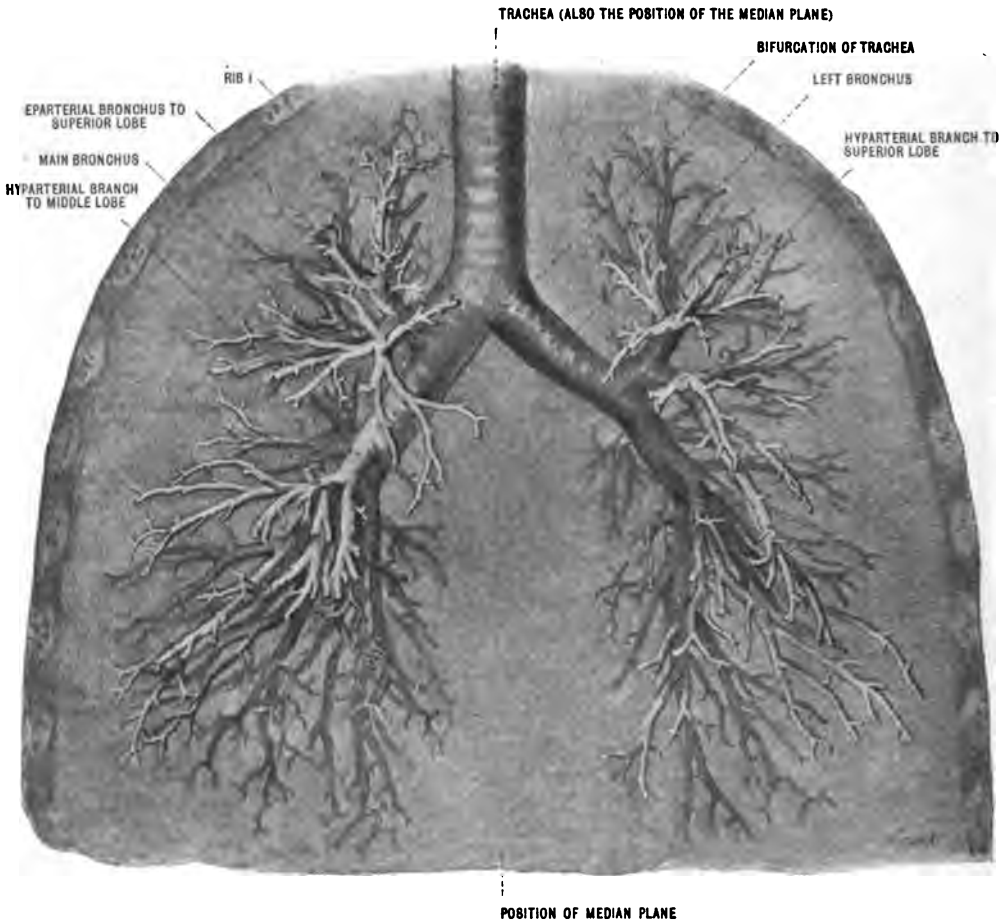
the bronchus, pulmonary artery and veins, bronchial vessels, lymphatic vessels and nodes, and pulmonary nerves. These are bound together by connective tissue and invested by the pleura. The bronchus is in the posterior and upper part of the root; the pulmonary vessels are in an anterior plane, the veins below the arteries.

The surface of the lung is marked off in polygonal areas of different sizes (secondary lobules) by lines containing pigment. The pigmentation is especially deep on the lateral surface along the furrows corresponding to the ribs.

Branching of the bronchial tubes (fig. 845).—Each bronchus, from its origin at the bifurcation of the trachea, takes an oblique course to the hilus, and then continues in the lung as a main tube, extending towards the posterior part of the base. These **stem-bronchi** are curved, probably in adaptation to the heart, the right like the letter **C** and the left like an **S**. Throughout their course the stem-bronchi give off in monopodic fashion collateral branches, and these, branching in a similar way, reach all parts of the lung.

The first lateral branch of the right stem-bronchus arises above the place where the latter is crossed by the pulmonary artery; it supplies the superior lobe of the right lung. A special branch goes to the apex. The second lateral branch goes to supply the middle lobe, while several lateral branches go to the inferior lobe. On the left side, the first lateral branch arises below the crossing of the pulmonary artery, and goes to supply the superior lobe, providing it with an apical ramus. The other lateral branches are given to the inferior lobe. When a cardiac lobe (see p. 1156) is present, its bronchus may come from the main stem-bronchus or from one of the collateral branches. A cardiac bronchus is, however, present in each lung, even though the lobe is not defined on the surface, and lies in the inferior lobe on the right side, in the superior lobe on the left. The larger bronchial tubes contain in their walls irregular plates of cartilage disposed

FIG. 845.—CAST OF THE AIR-TUBES AND THEIR BRANCHES, VIEWED FROM IN FRONT. (Spalteholz.)



on all sides. Internally and next to the mucosa is a continuous layer of smooth muscle-fibres circularly arranged. Mucous glands and lymph nodules are found, the former being present as far as tubes of 1 mm. diameter, where the cartilages also disappear.

To W. S. Miller is due the credit for having greatly increased our knowledge of the finer structure of the lung and for having presented the conception of the primary lung lobule now generally accepted by anatomists. Some of the chief results of Miller's work are embodied in the following description.

Through further branching a great number of very fine **bronchioles** are reached, and these, subdividing, give rise to the **respiratory bronchioles,** the walls of which are beset with alveoli (fig. 842). From the respiratory bronchioles arise the **aveolar**

ducts, or terminal bronchi, each of which leads to a group of air-spaces, called **atria,** each of which again communicates with a second series of air-spaces, the **alveolar saccules** or **air-sacs,** whose walls are pouched out to form numerous **alveoli** or **air-cells.**

A terminal bronchus with its air-spaces and blood-vessels, lymphatics and nerves, together form a **lobule** of the lung, the unit of lung structure.

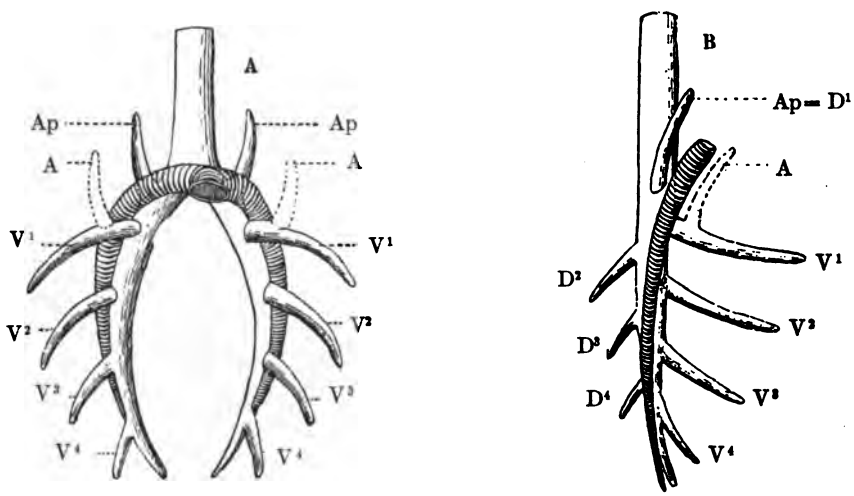
The collateral branches of the stem-bronchi arise in a dorsal and ventral series in the lower mammals, and the same arrangement, though less obvious, obtains in man.

Aeby divided the bronchial branches into two sets, according to their relation to the pulmonary artery. The branch arising above the place where the pulmonary artery crosses the stem-bronchus he named the **eparterial bronchus,** and those arising below the crossing he called **hyparterial.** An eparterial bronchus exists only on the right side; all the rest are hyparterial. Since the eparterial supplies the superior lobe of the right lung and no eparterial branch is present on the left side, Aeby concluded that the left lung had no lobe homologous with the superior lobe of the right lung. He compared the middle lobe of the right with the superior lobe of the left lung. According to the views of Aeby and Hasse, the first ventral branch of the right side is distributed to the middle lobe, while the remaining three ventral and all the dorsal lateral branches are given to the inferior lobe. On the left side, the first ventral branch is given to the superior lobe; the other ventral branches and the dorsal branches are distributed to the inferior lobe.

Narath considers the division of branches by their relation to the pulmonary artery to be of no great morphological significance. He attributes the apparent differences on the two sides to a shifting in position of homologous branches. Thus, Narath considers that the eparterial

FIG. 846.—SCHEME OF THE BRONCHIAL TREE ACCORDING TO NARATH. A. Anterior view. B. Right lateral view. (Poirier and Charpy.)

A. Apical bronchus, collateral of the first ventral and susceptible of becoming eparterial, Ap, in migrating to the bronchial trunk.



bronchus of Aeby has become the first dorsal lateral branch by displacement above the pulmonary artery and that it is homologous with an apical branch of the left side, which retains its primitive origin from the first ventral branch (fig. 846). Narath's conception of the migration of the bronchial branches is supported by the results of Huntington's extensive studies of the bronchial tree in mammals.

The physical properties of the lungs.—Volume and dimensions.—The average dimensions in the male are as follows: Height of the lung is given at 25–27 cm., the greatest sagittal diameter at 16–17 cm., and the greatest transverse measurement as 10 cm. for the right and 7 cm. for the left. The *volume* of the lungs when well expanded is 6500 c.c. (Merkel.) The *weight* of the lungs can be found only approximately on account of the presence of blood and mucus. In the adult male the weight of both lungs is given as 1300 gm.; female, 1023 gm. The weight of the right lung compared with the left is as 11 is to 10. Ried and Hutchinson found the weight of the lungs compared with that of the body as 1 : 37 (male), 1 : 43 (female); in the fœtus at term, 1 : 70.

Specific gravity.—The lung of an adult is much lighter than water, and therefore floats. Its specific gravity is between 0·345 and 0·746. (Rauber.) The

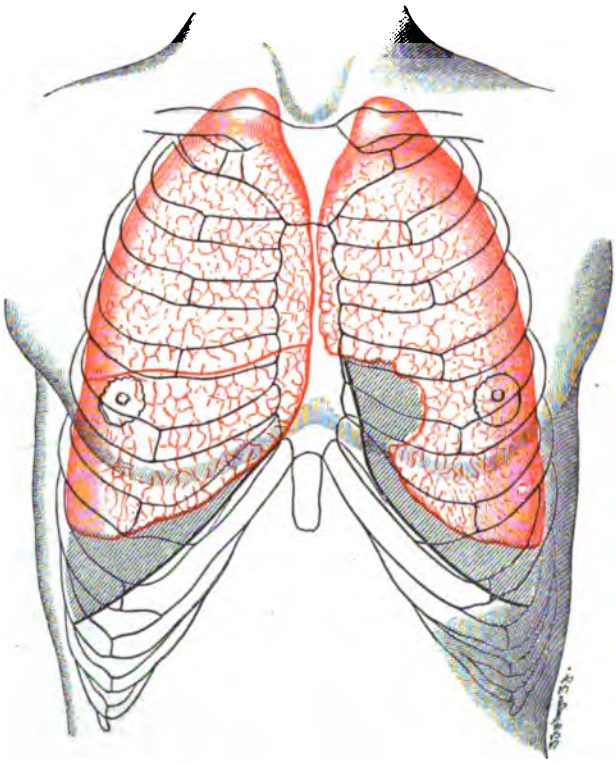
lung of the fœtus contains no air and is heavier than water. Its specific gravity is 1·045 to 1·056. (Krause.)

The **colour** of the lung is due to the presence of blood, pigment, and the air in the alveoli, and therefore varies, as these constituents are all or in part present and with differences in their proportions. Thus the general colour is red in the fœtus, pink in the infant, and grey mottled with black in the adult. The dark colour comes mostly from carbonaceous matter carried into the lungs from the atmosphere.

In **consistence** the lung is soft and spongy, and when compressed between the fingers, emits a crackling sound. Among the physical properties the **elasticity** of the lung is quite remarkable. Under ordinary conditions the pressure of the air in the lung keeps the air-cells and the organ as a whole distended, but when the pleura has been opened and the air pressure equalised within and without, the lung collapses.

Topography.—The **apices** of the lungs extend as high as the first thoracic vertebra, a level considerably higher than the superior margin of the sternum (figs. 847, 848). The subclavian vein and artery and the brachial plexus, together with the anterior scalene muscle, control to a certain degree the height reached. There

FIG. 847.—POSITION OF THE LUNGS FROM BEFORE. (Merkel.)
The parietal pleura is shaded and outlined in black.



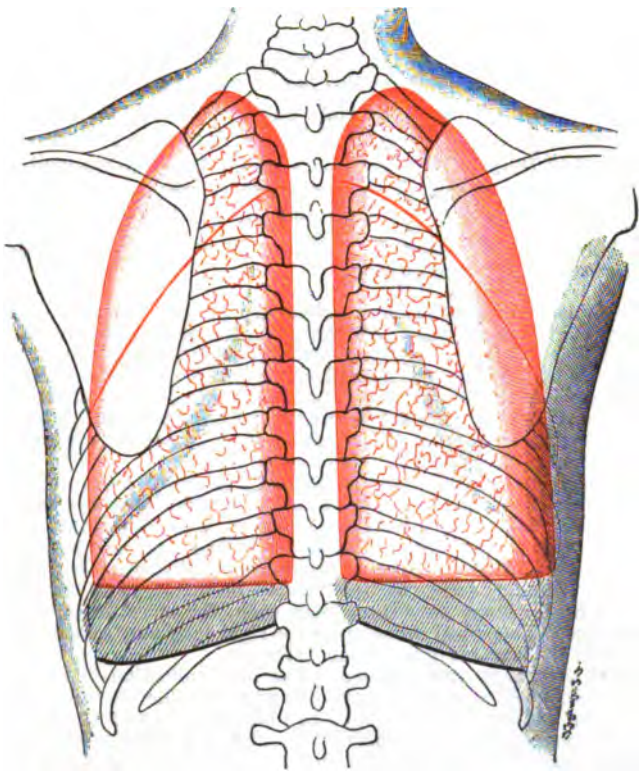
seems to be no constant difference between the levels attained by the apices of the two lungs. The height reached above the clavicle is rarely more than 3·5 cm. (Merkel), and will, of course, vary with individual differences in the position and form of this bone.

The **base** of the lung, resting on the diaphragm, is separated by that thin partition from the underlying abdominal viscera: thus beneath the base of the right lung is the right lobe of the liver, while under the left lung are the left lobe of the liver, the fundus of the stomach, and the spleen. The position of the apex changes very little in respiration, and the same holds true for the hinder bulky part of the lung. The latter rests against the side of the vertebral column in the deep hollow of the angles of the ribs, and reaches below to the level of the eleventh costo-vertebral joint (fig. 848). The **anterior margins** (fig. 847) descend in curves from behind

the sterno-clavicular joints, and run near together a little to the left of the median line. At the level of the sixth costo-sternal junction the anterior margin of the right lung turns lateralwards to follow the sixth costal cartilage. The anterior margin of the left lung turns lateralwards along the fourth costal cartilage as far as the parasternal line, descending in a curve to the lingula and thus forming the cardiac incisure. The **inferior margins** (figs. 847, 848) of the two lungs are alike in their positions, extending in a curve across the costo-chondral junction of the sixth rib to the superior margin of the seventh rib in the mammary line, and so to the ninth rib in the scapular line, whence they run horizontally medianwards to the eleventh costo-vertebral joint.*

The **interlobar fissure** (fig. 848) begins about six cm. below the apex, at the level of the third rib. A line drawn from the third dorsal spine to the root of the scapular spine would indicate the course of the upper part of this fissure. (Merkel.) Thence

FIG. 848.—POSITION OF THE LUNGS FROM BEHIND. (Merkel.)
The pleura is represented as in Fig. 847.



it passes downwards and around the chest to the end of the sixth bony rib in the mammary line. Merkel points out the use of the root of the scapular spine as a landmark for finding the limits of the lobes posteriorly: with the arm hanging at the side all above this spot is superior lobe; all below it the inferior. The short fissure of the right lung begins at the main interlobar fissure in the axillary line, about the level of the fourth rib or fourth interspace, and passes nearly horizontally to the anterior margin of the lung at the level of the fourth costal arch.

The **roots** of the lungs are placed opposite the fifth, sixth, and seventh dorsal vertebræ. The right root lies behind the inferior vena cava and under the arch of the azygos vein; the left root is beneath the aortic arch and in front of the thoracic aorta. The phrenic nerve passes in front of each root, the vagus behind. On the front and back are the pulmonary plexuses, anterior and posterior. The ligament of the pleura goes from the lower edge of the root.

* These relations are the mean between the conditions observed in the cadaver and as found by physical examination of the living.

Vessels and nerves of the lungs.—The **bronchial arteries** carry blood for the nourishment of the lungs and belong to the systemic system. They arise from the aorta or from an intercostal artery, two for the left lung and one for the right, and, entering at the hilus, reach the hinder wall of the main bronchus. The bronchial arteries accompany the bronchi, whose walls they supply, as far as the distal ends of the alveolar ducts, beyond which they do not go. (Miller.) These vessels also supply the lymph-nodes of the hilus, the walls of the large pulmonary vessels, and the connective-tissue septa of the lung. **Bronchial veins** arise from the walls of the first two or three divisions of the bronchi and end in the azygos or in one of the intercostal veins; those arising from the walls of the smaller tubes, including the alveolar ducts, join the pulmonary veins. The **pulmonary artery,** entering the hilus in a plane anterior to the bronchus, turns to the posterior aspect of the main-stem, following its branches and their subdivisions to the lobules. Entering the lobule, the last branch of the vessel gives off as many twigs as there are atria (fig. 842), and these twigs end in dense capillary nets in the walls of the alveoli. Here the venous blood brought by the pulmonary artery, separated from the air in the alveolus only by a thin septum, is changed to arterial blood by the respiratory process. The **pulmonary venous radicles** begin at the capillary networks and drain the arterial blood into the pulmonary veins, which run between adjacent lobules and which receive also blood coming from the capillary network of the pleura and from the capillary network of the bronchi (fig. 842). Thus it will be seen that while the pulmonary vein carries mostly arterial blood, it carries also some venous blood. The **pulmonary veins** follow the bronchial tree on the side opposite the arteries to the hilus, where, having converged to two large trunks located in the root of the lung below the plane of the artery, they pass to the left auricle. The pulmonary veins have no valves. According to Miller, anastomoses between the branches of the pulmonary artery are exceptional.

Anastomoses between the bronchial and pulmonary arteries have been described by many writers, among them C. Krause, Virchow, Küttner, and, recently, Zuckerkandl.

Lymphatics.—Miller has found the lymphatic vessels forming a closed tube system in the walls of the bronchi, in the pleura, and along the branches of the pulmonary artery and veins. They converge to empty into the bronchial nodes at the hilus and at the bifurcation of the trachea.

Nerves.—The vagus and sympathetic contribute to form the pulmonary plexuses in front and behind the root of the lung, from which branches go to accompany bronchial arteries; a smaller number accompany the air-tubes. (Berkley.)

Variations.—Congenital absence of one or both lungs is known, the latter condition, of course, being incompatible with extra-uterine life. Variations in the lobes are not uncommon—four for the right and three for the left lung has been recorded; a **cardiac lobe,** as found in certain mammals, sometimes occurs; and more or less complete fusion of the middle and upper lobes of the right lung is not rare. The lungs may be symmetrical, with two lobes each, and the apical bronchus of the right springing from the first ventral bronchus, as is normal for the left lung (Waldeyer, Narath); or the lungs have three lobes each, the apical bronchus of the left arising from the main bronchus. The apical bronchus of the right lung may arise from the trachea, an origin that is normal in the hog and other artiodactyls.

Development of the lungs and trachea.—The first indication of the trachea and lungs appears in embryos of about 32 mm. as a trough-like groove in the ventral wall of the upper part of the œsophagus, communicating above with the pharynx. Later the groove becomes constricted off from the œsophagus, the constriction extending from below upwards, so that a tube is formed which opens into the pharynx above. The lower end of this tube soon becomes bilobed, and the lobes, elongating, give rise to additional lobes, of which there are primarily three in the right side and two in the left. The upper unpaired portion of the tube becomes the trachea, while the lobed lower portion gives rise to the bronchi and lungs, the complicated structure of the latter being produced by oft-repeated branchings of the bronchi.

THE PLEURÆ

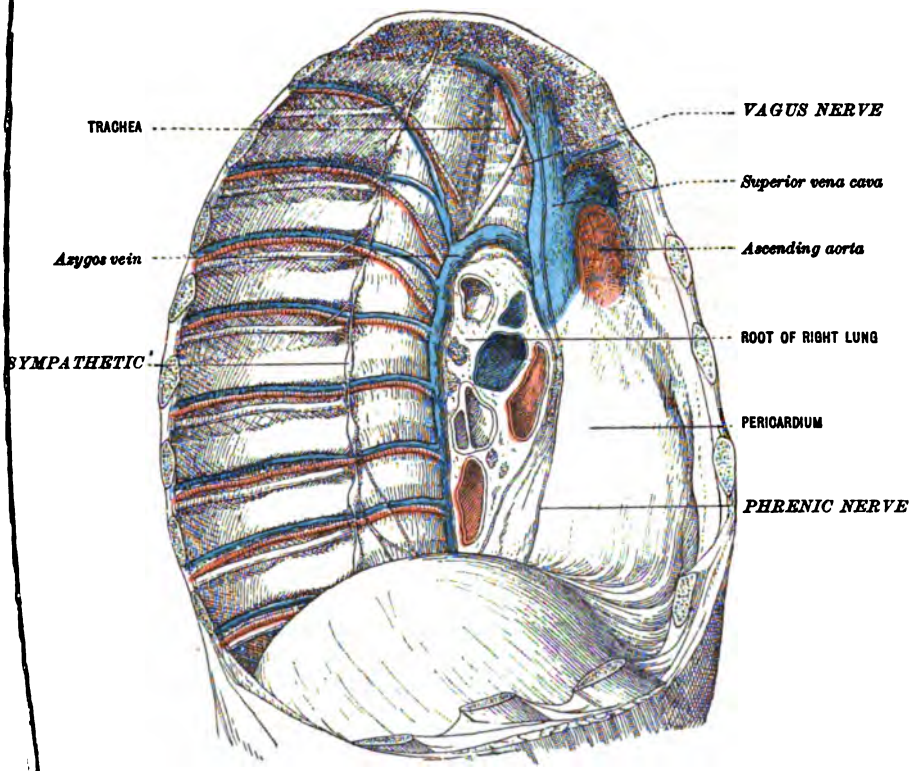
The **pleura** (fig. 843) is a serous sac, one wall of which closely invests the lung (**visceral pleura**), while the other lines the thoracic walls (**parietal pleura**), these parts being continuous the one with the other at the root of the lung. The **pleural cavity** is a capillary space containing a little fluid which lubricates the apposed surfaces of the visceral and parietal membranes. There are two pleuræ, one for each lung, completely separated by a sagittal partition, the **mediastinum,** which, extending from the spinal column to the sternum, is made up by the heart and great vessels and nerves, by the trachea, œsophagus, and related structures.

The **pulmonary** or **visceral pleura** covers closely the lung, to which it is firmly connected, extending into the fissures as far as they go, and providing a smooth,

glistening surface. At the hilus the visceral pleura leaves the mediastinal surface of the lung to cover the root above, in front, and behind. Below the root the pleura is reflected medialwards in a double layer as the **pleural** or **pulmonary ligament** (fig. 844). This presents anterior and posterior surfaces and three margins; the base is mostly free, and directed towards the diaphragm, with which it is connected at its medial end; the apex is at the lung root, one side is next to the lung, and the other against the mediastinum.

The **parietal pleura** is divided, according to the regions of the chest with which it is associated, into the costal, diaphragmatic, and mediastinal pleura. The **costal pleura** lines the thoracic wall, to which it is bound not very firmly by connective tissue (**fascia endothoracica**). It covers the back of the sternum in part and extends laterally upon the ribs and intercostal muscles. Posteriorly beyond the angles of the ribs it passes over the intercostal nerves and vessels, the heads of the ribs, and the sympathetic chain to the vertebral column; here it becomes continuous with

FIG. 849.—RIGHT LATERAL SURFACE OF THE MEDIASTINUM AFTER REMOVAL OF THE PLEURA. (Poirier and Charpy.)



the mediastinal pleura. Above, the pleura reaches beyond the superior margin of the sternum into the root of the neck, and in the form of a **cupola,** is adapted to the apex of the lung. It is supported by processes of the deep cervical fascia, and by a fibrous aponeurosis known as Sibson's fascia, coming from the scalenus minimus muscle and connected with the inner margin of the first rib. In relation to the pleural cupola are those structures already described as grouped about the lung apex: the brachial plexus, subclavian artery, anterior scalene muscle, and the subclavian vein, and, on the left side, the thoracic duct.

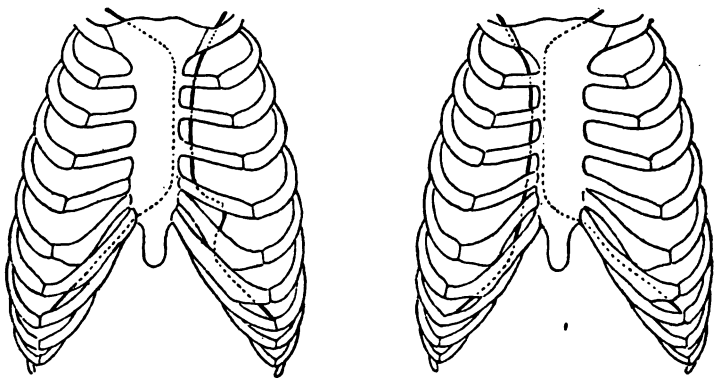
Below, the costal pleura is continuous with the **diaphragmatic pleura,** which adheres closely to the diaphragm and covers it, except in the pericardial area and where the diaphragm and thoracic wall are in contact.

The **mediastinal pleura** is reflected from before backwards at the sides of the mediastinum, covering the pericardium (*pericardial pleura*), to which it is closely adherent, and the other structures of the mediastinum, with which the two layers

are less firmly connected. Above the lung root the mediastinal pleura stretches directly from the spine to the sternum; but at the level of the root and below it, it is reflected laterally to the visceral pleura covering the root in front and behind and forming the pulmonary or pleural ligament. The right mediastinal lamina covers (fig. 849) the right innominate vein, the superior vena cava, the vena azygos, the trachea, the innominate artery, the right vagus and phrenic nerves, and the œsophagus. The left lamina lies against the left innominate vein, the aortic arch, the left subclavian artery, the thoracic aorta, the left phrenic and vagus nerves, and the œsophagus. About the base of the heart-sac are a number of fatty folds projecting from the pleura, the surfaces of which present some villous processes, the *pleural villi;* the latter also occur on the visceral pleura along the inferior margin of the lung.

The **lines of pleural reflexion** are of practical importance (figs. 847, 848, 850). Posteriorly, the costal pleura simply turns forwards in a gentle curve to become the mediastinal pleura, but anteriorly and inferiorly the membrane is folded upon itself, leaving an intervening capillary space, the **pleural sinus.** Such a space is present where the costal pleura is reflected upon the diaphragm (**phrenico-costal sinus**), the fold occupying the upper part of the angle between the chest-wall and diaphragm, the endothoracic fascia filling the lower part. The inferior margin of the lung enters this sinus a variable distance in inspiration. The line of the costo-diaphragmatic reflexion begins in front on the sixth costal cartilage, which it follows, descend-

FIG. 850.—MAXIMUM OF FLUCTUATION IN THE POSITION OF THE ANTERIOR LINES OF PLEURAL REFLEXION. (Tanja.)



ing obliquely to cross the seventh interspace in the mammary line. The greatest depth reached is at the tenth rib or interspace in the mid-axillary line. The line of reflexion then continues ascending slightly to the twelfth costo-vertebral joint.

The line of reflexion behind is sometimes found as low as the level of the transverse process of the first lumbar vertebra. Such a possibility must be reckoned in operating on the kidney. The twelfth rib therefore is not a reliable guide for the line of reflexion. It is not constant in its direction; it may be very small or absent altogether.

The lines of reflexion of the costal to the mediastinal pleura behind the sternum begin opposite the sterno-clavicular joints, descend obliquely to the level of the second costal cartilage, whence they run near together or in contact, but to the left of the median line, to the fourth cartilage. The reflexion on the *right* side continues from the sternum as far as the sixth rib cartilage, there turning laterally into the costo-diaphragmatic reflexion. The line on the *left* side, in the region of the cardiac notch (from the fourth to the sixth cartilages), is a little to the left of the sternal margin, and so a small area of the pericardium is left uncovered by pleura which is in contact immediately with the chest-wall. A reduplication of the pleura takes place along the anterior line of reflexion, and into the **costo-mediastinal sinus** so formed the thin anterior margin of the lung advances in inspiration. That part of the left sinus in front of the pericardium is not completely filled by the margin of the lung. These lines of reflexion are subject to variation the range of which, as determined by Tanja, is indicated in fig. 850.

The vascular networks of the visceral pleura are derived from the pulmonary artery, and the blood is carried back by veins which enter the lung. (See radicals of the pulmonary vein on page 1156.) (Miller.) The parietal pleura is supplied by **arteries** from several sources: internal mammary, intercostals, phrenics, mediastinal, and bronchial. The **veins** correspond to the arteries.

The **lymphatics** of the visceral pleura form rich networks without definite relations to the lobules of the lung. They accompany the radicles of the pulmonary veins and drain into the bronchial lymph-nodes. In the parietal pleura lymph-vessels are present most abundantly over the interspaces; they empty into the sternal and intercostal nodes. The **nerves** supplied to the visceral pleura are branches from the pulmonary plexus; to the parietal pleura, from the intercostals, vagus, phrenic, and sympathetic.

Mediastinum (figs. 843, 844).—An arbitrary subdivision of the interval between the mediastinal pleuræ into anterior, middle, posterior, and superior mediastinal spaces has long been customary, and is useful for descriptive purposes.

The **superior mediastinum** is that part of the mediastinum which lies above the level of the pericardium. It extends from the vertebral column behind to the sternum in front, and contains the aortic arch and the great vessels arising from it, the innominate veins, and the upper part of the superior vena cava, the thoracic duct, the lower portion of the trachea, and a portion of the œsophagus, the phrenics, vagi, left recurrent and cardiac nerves, and the thymus gland.

From the superior mediastinum the other three divisions of the space extend downwards. The **anterior mediastinum** lies between the pericardium and the sternum; it contains some lymphatic nodes and some branches of the internal mammary vessels. The **middle mediastinum** lies between the mediastinal pleuræ in front of the root of the lungs; it contains the heart, enclosed in the pericardium, and the phrenic nerves. The **posterior mediastinum** lies between the mediastinal pleuræ behind the roots of the lungs; it contains the œsophagus, the thoracic aorta, thoracic duct, the azygos and hemi-azygos veins, and the vagus nerves.

SECTION X

THE URINARY AND REPRODUCTIVE ORGANS

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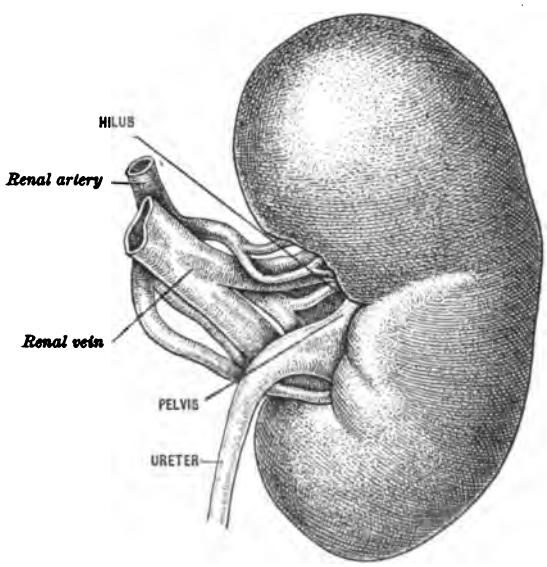
THE URINARY APPARATUS

THE urinary apparatus consists of the **kidneys**—two glandular organs situated in the loins behind the peritoneum, each of which is provided with a duct—the **ureter**—for the passage of the secretion to a reservoir—the **bladder**—from which it is periodically expelled from the body through a tube of outlet—the **urethra.**

FIG. 851.—POSTERO-INTERNAL ASPECT OF THE LEFT KIDNEY.



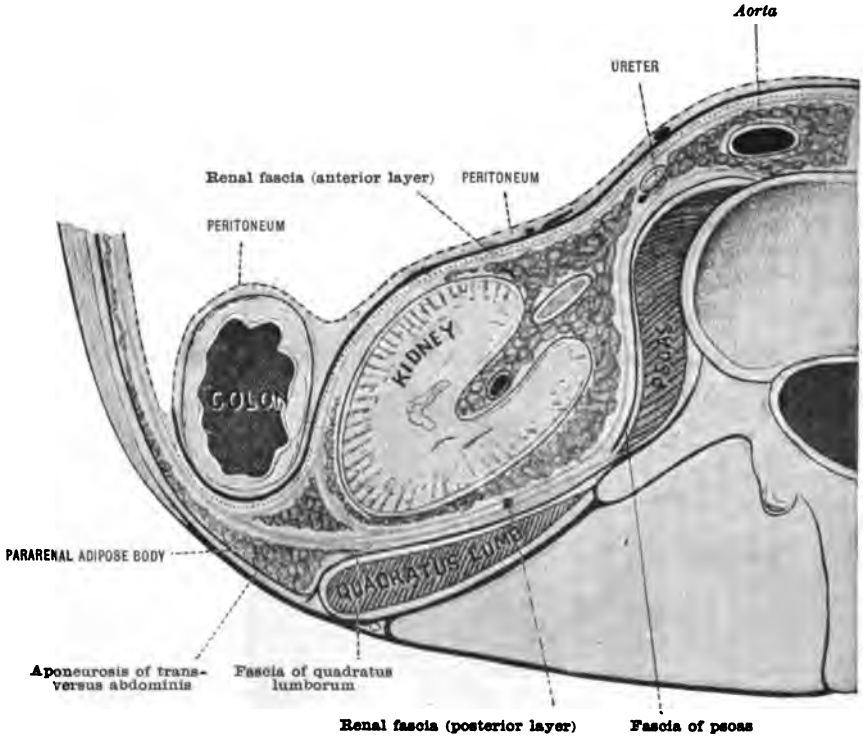
THE KIDNEYS

Physical characters.—In its typical form each **kidney** is bean-shaped. Its long axis is directed from above downwards and slightly laterally; its surfaces look dorsally and ventrally; its convex border is directed laterally; and upon its medial concave border, usually somewhat towards the anterior surface, there is a depression, the **hilus,** leading to a cavity, called the **sinus,** in which lie the renal vessels,

nerves, and duct. The length of the kidney in the male averages 10–12 cm. (4½ in.), its breadth about 5·5 cm. (2¼ in.), its thickness 3 cm. (1⅛ in.), and it weighs 110–150 gm. (about 5 ounces). The dimensions of the female kidney differ little from those of the male, but its weight is from one-seventh to one-fifth less. In the child the organ is relatively large, its weight compared with that of the entire body being about 1 : 133 at birth, but its permanent relation, which is about 1 : 217, is usually attained at the end of the tenth year of life.

It offers for description two surfaces, two extremities, and two borders. The **anterior** or **visceral surface** is convex, and looks obliquely forwards and outwards; the **posterior** or **parietal surface,** less convex than the anterior, looks inwards and backwards; the rounded **upper extremity** is usually somewhat larger than the lower, and is placed about 1·2 cm. (½ in.) nearer to the median sagittal plane of the body. The **external border** is narrow and convex. The **internal border** or (surface), looking forwards, inwards, and slightly downwards, is relatively broad, and is fissured vertically in the middle third of its length by the hilus.

FIG. 852.—DIAGRAM SHOWING RELATION OF KIDNEY TO CAPSULE. (Gerota.)



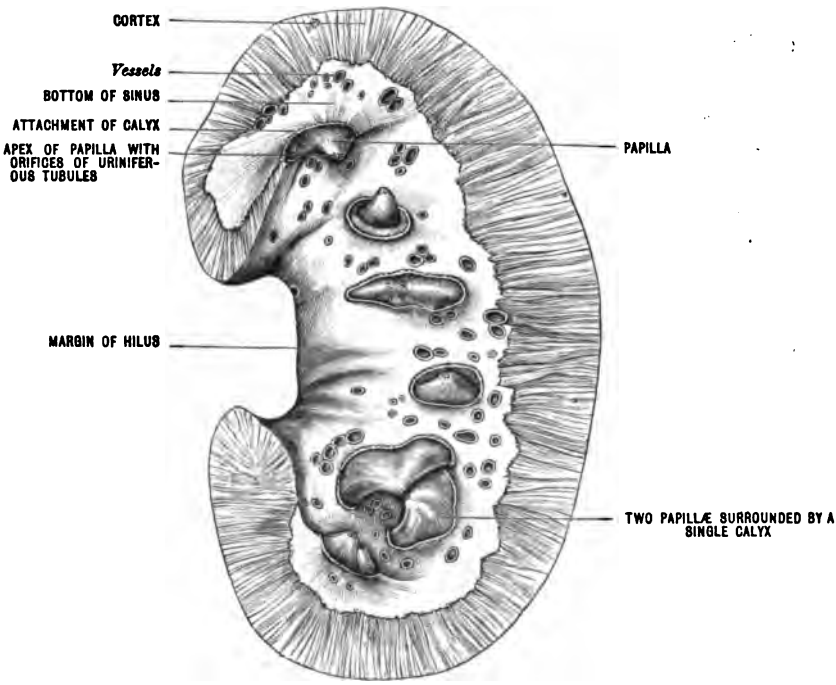
The **hilus** (fig. 851) is a slit-like aperture bounded in front and behind by rounded lips of variable and unequal thickness. The posterior lip is nearer to the middle line than the anterior, and between the two pass the renal vessels and nerves, the ureter, and a quantity of fat-bearing connective tissue. The **sinus** (fig. 853), occupied by the vessels and nerves just mentioned and by a dilatation of the upper end of the ureter, known as the **renal pelvis,** is narrowest near its entrance, and about 25 mm. (1 in.) in depth. Its fundus is pierced by the renal vessels and nerves, and by the uriniferous tubules; and gives attachment to the primary branches (**calyces**) of the pelvis.

Investment and fixation.—The entire surface of the kidney, including the sinus, is covered by a thin but strong **fibrous capsule,** which may be readily peeled off from the healthy kidney, except at the bottom of the sinus, where it is adherent to the renal vessels and the calices. As the blood-vessels which pass to it from the kidney substance are small, the process of stripping is attended with little hæmorrhage when performed in the course of operations on the living subject. External to the fibrous

capsule is a quantity of adipose tissue, which forms a complete investment for the organ, the **adipose capsule,** and is prolonged through the hilus into the sinus.

The peritoneum, which covers the anterior surface of the adipose capsule, has usually been regarded as the principal means of fixation of the kidney, but in reality this is accomplished by means of a special **renal fascia** (fig. 852), developed from the subperitoneal areolar tissue (Gerota). Lateral to the kidney there occurs between the transversalis fascia and the peritoneum a subperitoneal fascia, which, as it approaches the convex border of the kidney, divides into two layers, one of which passes in front of and the other behind the kidney, enclosing the adipose capsule. Traced medially, the **anterior layer** of the **renal fascia** passes in front of the renal vessels, and, over the aorta, becomes continuous with the corresponding layer of the opposite side; upwards, it passes over the suprarenal gland and at the upper border of that organ becomes continuous with the posterior layer; and downwards, it is lost in the adipose tissue intervening between the iliac fascia and muscle. The **posterior layer,** which is the thicker of the two, passes medially behind the renal vessels and is lost in the connective tissue in front of the vertebral column, and below it is lost, like the anterior layer, in the iliac region. Behind the posterior layer, between it and the quadratus lumborum, is a mass of adipose tissue, the **pararenal adipose body,** and both layers are united to the fibrous capsule of the kidney by trabeculæ of connective tissue which traverse the adipose capsule.

FIG. 853.—SECTION OF KIDNEY SHOWING THE SINUS. (After Henle.)



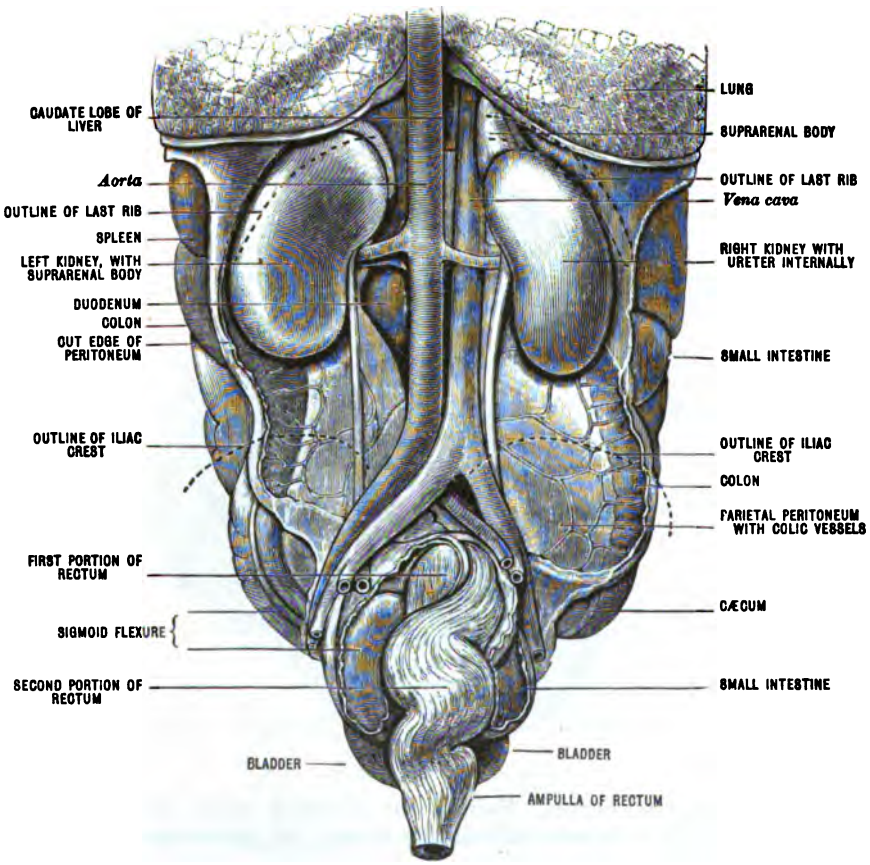
Each kidney is, accordingly, supported by these trabeculæ in a space bounded laterally and above by the layers of the renal fascia, and open medially and below. Should these trabeculæ become atrophied by wasting disease or ruptured by the pressure of the pregnant uterus, by the improper use of corsets, or by any other cause, the phenomenon of movable or wandering kidney may be set up by slight external violence, the organ tending to shift its place as far as the attachment of its vessels to the main trunks and the arrangement of the renal fascia will permit.

Position and relations.—The kidney is commonly said to lie in the lumbar region. It is, however, intersected by the horizontal and vertical planes which separate the hypochondriac, lumbar, epigastric, and umbilical regions from each other, and hence belongs to all these segments of the abdominal space. Its vertical level may be said to correspond to the last thoracic and two upper lumbar verte-

bræ, the right lying in most cases from 8 to 12 cm. (⅓ to ½ in.) lower than the left, but exceptions to this rule are not unfrequent.

The **posterior surface** (figs. 854, 855), with the corresponding portion of the fatty capsule and the pararenal adipose body, rests against the posterior abdominal wall, extending upwards in front of the eleventh and twelfth ribs and inwards to overlap the tips of the transverse processes of the first and second lumbar vertebræ; the left kidney usually reaching as high as the upper border of the eleventh rib, the right only to its lower border. The only visceral relation posteriorly is on the left side, where the spleen slightly overlaps the kidney opposite the upper half of its outer border. The parietal relations on both sides are as follows:—(1) the diaphragm, and if a well-marked *hiatus diaphragmaticus* exist above the external lumbo-costal arch (arcuate ligament), the kidney may come into relation with the subpleural tissue

FIG. 854.—THE ABDOMINAL VISCERA, SEEN FROM BEHIND.
(From the model of His.)
The kidneys are somewhat lower than usual in their relations to the ribs.



and pleura; at this point the chest may become invaded by a circumrenal abscess, or an empyema may find its way from the pleura into the subperitoneal tissue behind the kidney; (2) the anterior lamella of the posterior aponeurosis of the transversalis (separating the organ from the quadratus lumborum); (3) the psoas; (4) the three fascia—diaphragmatic, transversalis, and iliac—which line these muscles respectively; and (5) the last thoracic, the ilio-hypogastric, and the ilio-inguinal nerves, and the anterior divisions of the subcostal and first lumbar vessels, all running obliquely downwards and outwards in front of the quadratus lumborum to pierce the transversalis beyond the outer border of the quadratus. Owing to the higher level of the left kidney, its diaphragmatic area of contact is larger than that of the right organ. This area, moreover, may be increased on either side when the lumbo-costal arches (arcuate ligaments), which give origin to a large portion of the posterior fibres

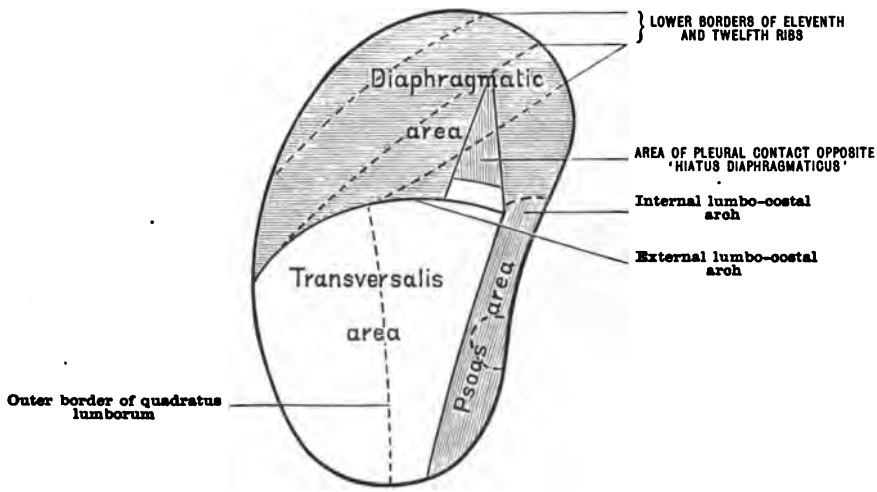
of the diaphragm, are attached to the tip of the transverse process of the second lumbar vertebra instead of to that of the first.

The pleura has an indirect but important relation to the kidney besides the more direct relation at the hiatus diaphragmaticus referred to above. The inferior limit of the pleural sac extends almost horizontally outwards from the lower border of the twelfth thoracic vertebra, crossing the last rib near its neck, and the eleventh rib about 5 cm. (2 in.) farther outwards. As a rule, the incision in renal operations may be carried safely to the lower border of the last rib; but, should this bone be absent or very short, the eleventh rib may be mistaken for it, and the serous membrane would then be in danger. It is probable, too, that the pleura reaches to a lower point in those cases where the lumbo-costal arches are attached to the second lumbar transverse process. The presence of a thirteenth rib would involve a contraction of the space available for the surgical exploration of the organ.

The **upper extremity** of each kidney is crowned by the suprarenal body (figs. 854, 856), which encroaches also upon its anterior surface and inner border, and is fixed to it by connective tissue derived from the subperitoneal fascia.

The **anterior** or **visceral surface** (fig. 856) is moulded to the contiguous organs. The *right* kidney is in contact in about its upper half with the renal impression on the liver (page 1118), and below with the ascending colon and duodenum;

FIG. 855.—DIAGRAM OF RELATIONS OF POSTERIOR SURFACE OF LEFT KIDNEY.



the hepatic area being covered with peritoneum, while the descending portion of the duodenum and, more externally, the ascending colon are directly attached to the surface by subperitoneal tissue; but the two non-peritoneal areas vary considerably in their relative proportions, not only in different subjects, but in the same subject under different conditions of distension of the duodenum and the colon. The descending portion of the duodenum is also more or less in relation with the right renal vessels.

The *left* kidney lies behind the stomach, the pancreas, the splenic vessels, the descending colon, and the colic vessels. Its anterior surface may be divided into three portions: an **upper** or **gastric area,** separated from the stomach by the peritoneum of the lesser sac; a **middle** or **pancreatic area,** attached to the pancreas by subperitoneal connective tissue, and crossed also by the splenic vein behind the upper border of the pancreas, and by the splenic artery, which runs in a serpentine course immediately above the vein; and an **inferior** or **colic area,** the outer portion of which is covered by the splenic flexure and upper part of the descending colon; the inner by a layer of peritoneum (of the greater sac) and the left colic vessels.

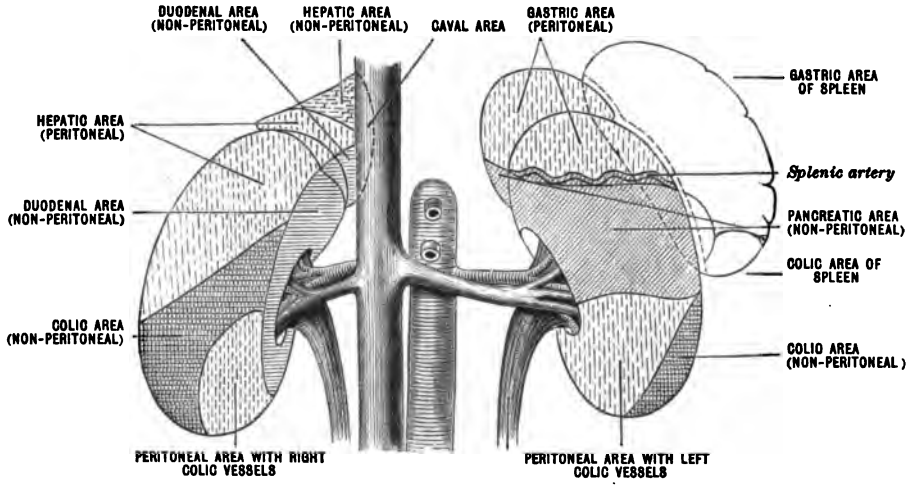
The **outer border** of the kidney reaches a point about 8·5 or 10 cm. (3½ or 4 in.) external to the lumbar spinous processes. On the right side, it is in contact with the liver in its upper half or two-thirds; on the left, its upper third or half rests against the renal groove in the posterior portion of the visceral surface of the spleen.

The **inner border** of the right kidney approaches very close to the vena cava, especially above; that of the left is separated from the aorta by an interval of 2·5 cm. (1 in.) or more.

The position of the kidneys at the back of the abdominal cavity involves a certain amount of pressure upon the organs and their vessels and nerves by the weight of the viscera in front when the body is supine, and there is reason to believe that their secretory functions are consequently influenced by changes of posture to an extent that may be utilised in therapeutics.

Structure.—On section through the kidney, its substance is found to comprise an external or *cortical* and an inner or *medullary* portion (fig. 857). The **medulla** consists of a variable number (eight to eighteen) of conical segments called **renal pyramids** (pyramids of Malpighi), the apices of which project into the bottom of the sinus (fig. 853) and are surrounded by the primary segments (**calices**) of the pelvis, while their bases are turned towards the surface, but are separated from it and from each other by the **cortex.** The **pyramids** average in their axial diameter about 18 mm. (¾ in.) and have a width at the base of about 16 mm. (⅔ in.). They are smooth and somewhat glistening in section, and marked with delicate striæ which converge from base to apex and indicate the course of the uriniferous tubules. The blunted apex, or **papilla,** single or blended with one or even two of its fellows,

FIG. 856.—DIAGRAM SHOWING ANTERIOR RELATIONS OF KIDNEYS AND SUPRARENAL BODIES.



is embraced by a **calyx,** and, if examined with a hand-lens, will be seen to present a variable number (twelve to eighty) of minute apertures, the **foramina papillaria,** through which the secretion escapes into the pelvis.

The **cortex** may be divided into two portions: a peripheral layer, the **cortex proper,** which is 12 mm. (½ in.) in thickness, and extends from the capsule to the bases of the pyramids; and processes called **renal columns (columns of Bertin),** which dip inwards between the pyramids to reach the bottom of the sinus, where they are covered by the fibrous capsule and more or less adipose tissue (fig. 857). In section the cortex is somewhat granular in aspect, and in an injected kidney is seen to be dotted with minute points corresponding to vascular glomeruli lying within the cæcal origin of the renal tubules (capsules of Bowman). Examined more closely, it shows a differentiation into a number of imperfectly separated portions termed **cortical lobules.** Each of these is composed of a **convoluted portion,** surrounding an axial **radiate portion** (pyramid of Ferrein). The latter consists of a group of tubules which extend from the cortex into the base of one of the medullary pyramids, whence it is also termed a **medullary ray,** and each medullary pyramid is formed from the rays of a number of cortical lobules, these structures, therefore, greatly exceeding the pyramids in number.

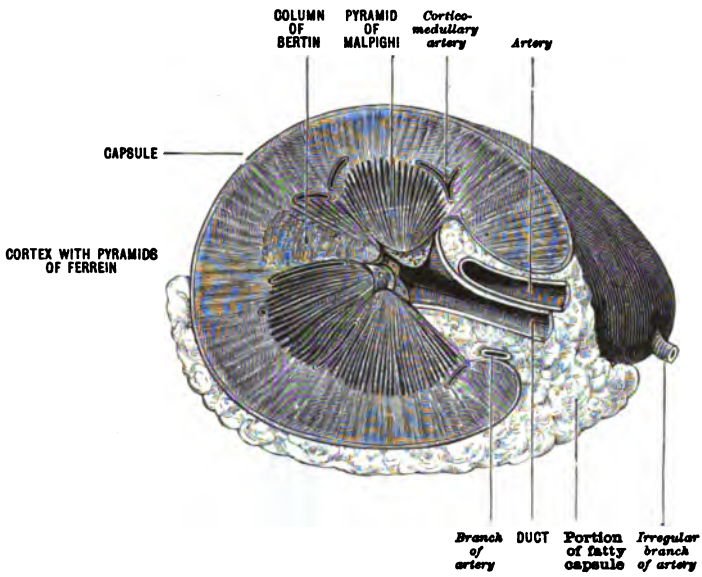
Renal tubules (fig. 585).—Each of the renal tubules, which constitute the essential structures of the kidney, commences in a spherical **glomerular capsule** (fig. 585), one wall of which is invaginated by a small glomerulus of blood-vessels, the combination of glomerulus and capsule forming what is termed a **renal (Malpighian) corpuscle.** These corpuscles are situated in

the convoluted portions of the cortical lobules, and from each there arises by a narrow neck a tubule, which becomes wide and convoluted, the **first convoluted tubule**, and enters a medullary ray. There it narrows again and descends as a straight tubule, the **descending limb of Henle's loop**, into the subjacent medullary pyramid, and, turning upon itself, forming the **loop of Henle**, ascends to the cortex, where it again becomes wide and contorted, forming the **second convoluted tubule**. This again lies in the convoluted portion of the cortical lobule, and, becoming narrower, opens with other tubules into a **straight or collecting tubule**, which occupies the axis of the medullary ray, descends into the subjacent medullary pyramid, unites with other collecting tubules, and finally opens into the renal pelvis at the summit of a papilla.

The tubules are lined with epithelium throughout, the cells being tesselated in the capsule, irregularly cubical in the convoluted tubules and ascending limbs, flattened on the descending limbs and loops of Henle, and columnar in the cortical collecting tubules and in the straight tubules of the medulla.

Vessels (fig. 858).—The kidney is very vascular. The larger arterial branches, arranged in the sinus as has already been described, enter the substance of the kidney and pass up as the **interlobar arteries** in the renal columns. On reaching the bases of the pyramids they bend so as to run horizontally between these and the cortex, forming the **arcuate arteries**, from which **interlobular** branches pass up into the cortex and supply **afferent** branches to the Malpighian glomeruli, from which numerous branches, the **arteriolæ rectæ**, pass down into the pyramids, supplying the tubules of which these are composed. **Efferent** stems which issue from the Malpighian glomeruli break up into capillaries which supply the tubules contained in the cortex. **Veins** corresponding to the arteriolæ rectæ and to the interlobular, arcuate, and interlobar arteries occur, opening into the renal veins, and, at the surface of the kidney, arranged in star-like groups,

FIG. 857.—HORIZONTAL SECTION OF KIDNEY, SHOWING THE SINUS.



are the **stellate veins**, which open into the interlobular veins and also communicate with the veins of the adipose capsule. The renal **lymphatics** may be divided into two sets, capsular and parenchymatous. They terminate in the upper lumbar nodes.

Nerves.—The nerves form a plexus accompanying the vessels, and are derived from the sympathetic through the renal plexuses.

Variations.—The kidney of a fœtus differs from that of the adult in being divided into a number of renal lobes, each of which corresponds to the base of a renal pyramid and is capped by a thin layer of cortex. Such a condition is permanent in some of the lower animals; but in man the superficial indications of morphological segmentation usually become obliterated during the progress of growth of the cortical tissue, and are seldom visible after the age of ten.

In the development of the embryo representatives of three different sets of excretory organs occur, the kidney (**metanephros**) being the last to form. The two earlier sets (**pronephros** and **mesonephros**) have a common duct, the Wolffian duct, and from the lower end of this an outgrowth developes, which extends upwards on the posterior abdominal wall and comes into connection with a mass of embryonic tissue known as the **metanephric blastema**. The outgrowth gives rise to the ureter, pelvis, and collecting tubules, while the remaining portions of the tubules are formed from the blastema.

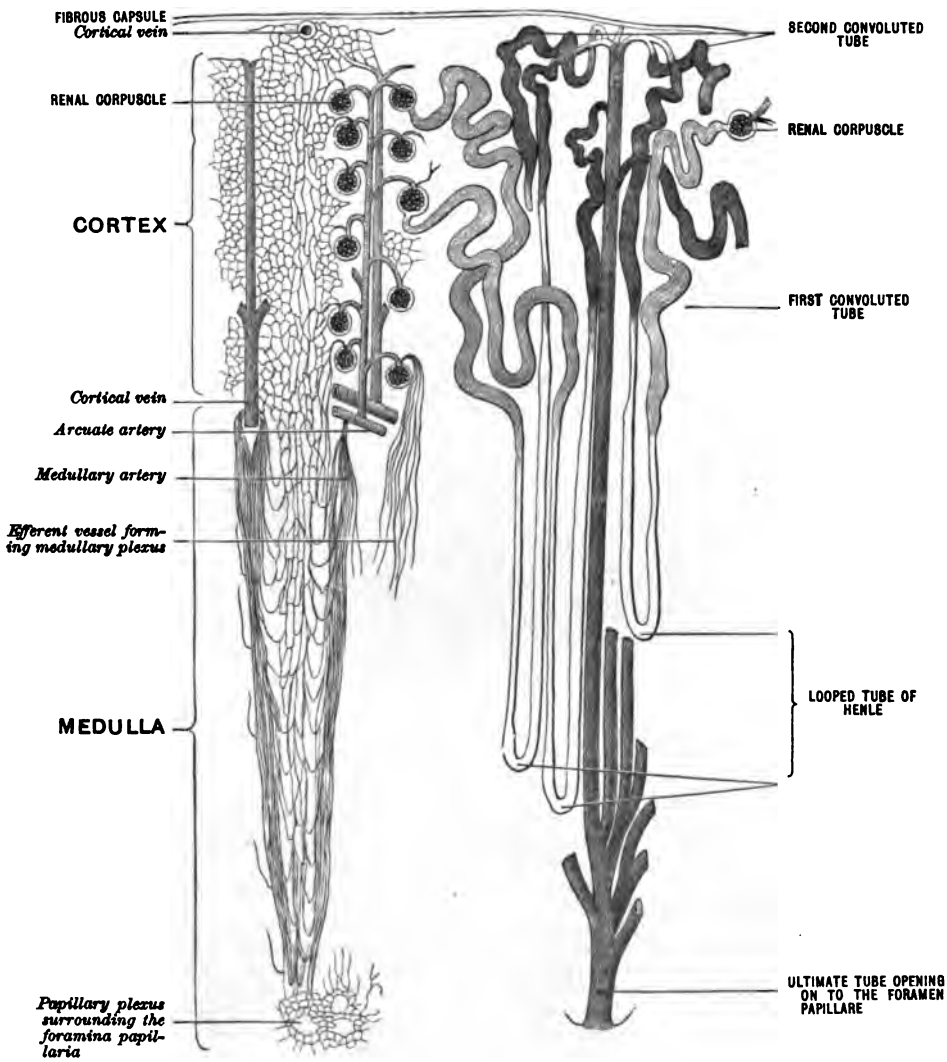
Various abnormalities may result from modifications of the development of the kidneys. (1) Occasionally the ureteric outgrowth of one side fails to develope, the result being the occurrence of a *single kidney*. (2) The blastema may fail to attain its normal position, in which case the kidney may be situated in the iliac region or even in the pelvis; or the blastema may be drawn into an unusual position, the kidney resting on the vertebral column, or even in the opposite side of the abdomen; (3) or the two blastemas may fuse to a greater or less extent, forming a 'horse-

shoe kidney' extending across the verbebral column, or, if the fusion be more extensive, an apparently single kidney, which may rest upon the vertebral column, or to one side of it. Such *fused kidneys* may be distinguished from single kidneys by the fact that they possess two ureters, which open normally into the bladder. (4) Finally, in rare cases, a blastema may become divided, an **accessory kidney** of varying size being thus produced.

THE URETERS

The **ureter** (figs. 851, 854, 862), which serves as the excretory duct of the kidney, is a musculo-mucous canal, expanded and irregularly branched above, narrow and of fairly uniform dimensions in the rest of its course. At its origin in the renal sinus it consists of a number of short tubes, usually eight or nine, called

FIG. 858.—SCHEME OF TUBULES AND VESSELS OF THE KIDNEY.



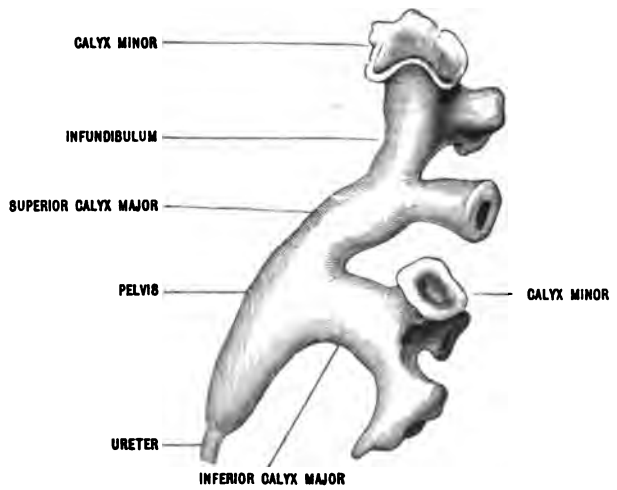
calyces minores, each of which embraces a renal papilla 4 or 6 mm. above its apex, or occasionally two papillæ may be connected with a single calyx. The calyces minores average about 8 to 12 mm. ($\frac{1}{3}$ to $\frac{1}{2}$ in.) in length, and open directly or by means of intermediate tubes (**infundibula**) into two short passages, the **superior** and **inferior calyces majores,** which in turn combine after a longer or shorter course to form the **pelvis.** The inferior and larger calyx major has a diameter of about 10 mm. ($\frac{2}{5}$ in.); the superior is about one-third less. Occasionally a third or **middle calyx major** is present.

The **pelvis** varies greatly in different subjects. It usually appears as a more or less funnel-shaped portion of the canal, wider above (about 15 mm.), where it lies between the two lips of the hilus; narrow below, where it arches downwards and inwards to become continuous with the relatively uniform portion of the duct known as the **ureter.** In some cases, however, it can scarcely be said to exist as a dilatation. Under ordinary circumstances it is flattened from before backwards, its anterior and posterior walls being in contact, and its channel represented by a fissure. It is in relation behind with the posterior lip of the hilus, from which it is separated by more or less adipose tissue continuous with the fatty capsule, and occasionally by an irregular branch of the renal artery. The main stems of the renal vein and artery lie in front, imbedded in fat, and anterior to these structures is situated the descending portion of the duodenum on the right side, and the pancreas on the left.

The **ureter** extends from the termination of the pelvis to the bladder, running between laminæ of the subperitoneal tissue. It is a tube of about 5 mm. ($\frac{1}{5}$ in.) in diameter when distended, and is fairly uniform in size, except that a constriction occurs where it joins the pelvis, and a second one at about the middle of its abdominal portion. Its length is variously stated, but the average in the male adult may be taken as about 30 mm. (12 in.), the right being usually a little the shorter.

Course and relations.—The ureters lie about 7·5 cm. (3 in.) apart at their

FIG. 859.—UPPER PORTION OF DUCT. (After Henle.)



commencement, but this distance gradually lessens to about 5 cm. (2 in.) as they descend towards the sacro-iliac joint. In the true pelvis they at first diverge, but finally on nearing the base of the bladder they run forwards and inwards to pierce the wall of that viscus, and at their termination are separated by a distance of about 2·5 cm. (1 in.). The course of each ureter may be conveniently divided into three portions, abdominal, pelvic, and vesical. The **abdominal portion,** running downwards and slightly inwards, is in relation, *posteriorly*, with the psoas and its fascia; it crosses obliquely the genito-femoral (genito-crural) nerve, and below passes in front of the common iliac artery near its bifurcation. *Anteriorly*, it is covered by peritoneum and intestines, and is crossed by the ileo-colic and spermatic (ovarian) vessels. *Internally*, it is in relation on the right side with the inferior vena cava, on the left with the aorta, the vein being almost in contact with the right ureter, while the artery is separated from the left one by an interval that gradually diminishes from 2·5 cm. (1 in.) above, to 1·5 cm. ($\frac{1}{2}$ in.) opposite the bifurcation of the vessel.

The **pelvic portion** runs in front of the sacro-iliac synchondrosis, then upon the obturator internus and its fascia behind and below the psoas, crossing the obturator vessels and nerve and having to its inner side the pelvic coils of intestine (sigmoid colon on left side, small intestine on right), and, finally, it leaves the pelvic wall at about the level of the ischial spine to pass towards the bladder. In this position,

in the *male*, it is crossed superiorly and internally by the vas deferens, and then passes under cover of the free extremity of the vesicula seminalis, separated from its fellow by a distance of 37 mm. (1½in.). In the *female* it runs parallel with, and 8 to 12 mm. (⅓ to ½ in.) distant from, the cervix uteri, passes behind the uterine artery, through the uterine plexus of veins, and beneath the root of the broad ligament, and finally crosses the upper third of the lateral wall of the vagina to reach the vesico-vaginal interspace and pierce the bladder opposite the middle of the vagina. A calculus in the lower end of the tube might be detected by a vaginal examination.

The **vesical portion,** about 12 mm. (½ in) in length, runs obliquely downwards and inwards through the coats of the bladder, and opens on its mucous surface about 18 to 25 mm. (¾ to 1 in.) from both its fellow and the internal urethral orifice.

Structure.—The wall of the ureter is about 1 mm. ($\frac{1}{25}$ in) in thickness, and consists of a mucous membrane, a muscular coat, and an external connective tissue investment. The **mucous membrane** is longitudinally plicated, and is lined by transitional epithelium, continuous with that of the papillæ above and with that of the bladder below. Mucous follicles of simple form have been found in the upper part of the canal. The **muscularis** is about 0.5 mm. ($\frac{1}{50}$ in.) in thickness, and consists of two layers, an external, composed of annular fibres, an internal, of fibres longitudinally disposed. After the tube has entered the bladder the circular fibres form a kind of sphincter around its vesical orifice; while the longitudinal fibres are continued onwards through the wall of the bladder and terminate beneath its mucous membrane.

Vessels and nerves.—The **arteries** supplying the pelvis and upper part of the ureter come from the renal; the rest of the abdominal portion of the ureter is supplied by the spermatic (ovarian), and its pelvic portion receives branches from the middle hæmorrhoidal and inferior vesical; the veins terminate in the corresponding trunks; and the **lymphatics** pass to the lumbar and hypogastric nodes. The **nerves** are supplied by the spermatic, renal, and hypogastric plexuses.

Variations.—Occasionally the depression which separates the two calyces majores extends through the pelvis, so that the calyces appear to open directly into the ureter. The fission may also affect the ureter to a greater or less extent, in extreme cases producing a duplication of the tube throughout its entire length.

THE BLADDER

The **urinary bladder** is a receptacle, of which the form, size, and position vary with the amount of its contents. The adult organ in its empty or moderately filled condition lies entirely below the level of the oblique plane of the pelvic inlet; but when considerably distended it rises into the abdomen and shows itself beneath the parietes as a characteristic mesial projection above the symphysis, a projection which in certain cases may extend nearly to the level of the umbilicus. It is invested over its whole extent by the endopelvic (recto-vesical) fascia, and is covered above and behind by peritoneum (fig. 860).

Form.—When fully distended it assumes in the male an ovoid shape with its longest diameter directed downwards and backwards, but in woman the transverse diameter is commonly the greatest, owing to the different shape of the pelvic cavity. In the child it is somewhat pear-shaped, the stalk being represented by the urachus.

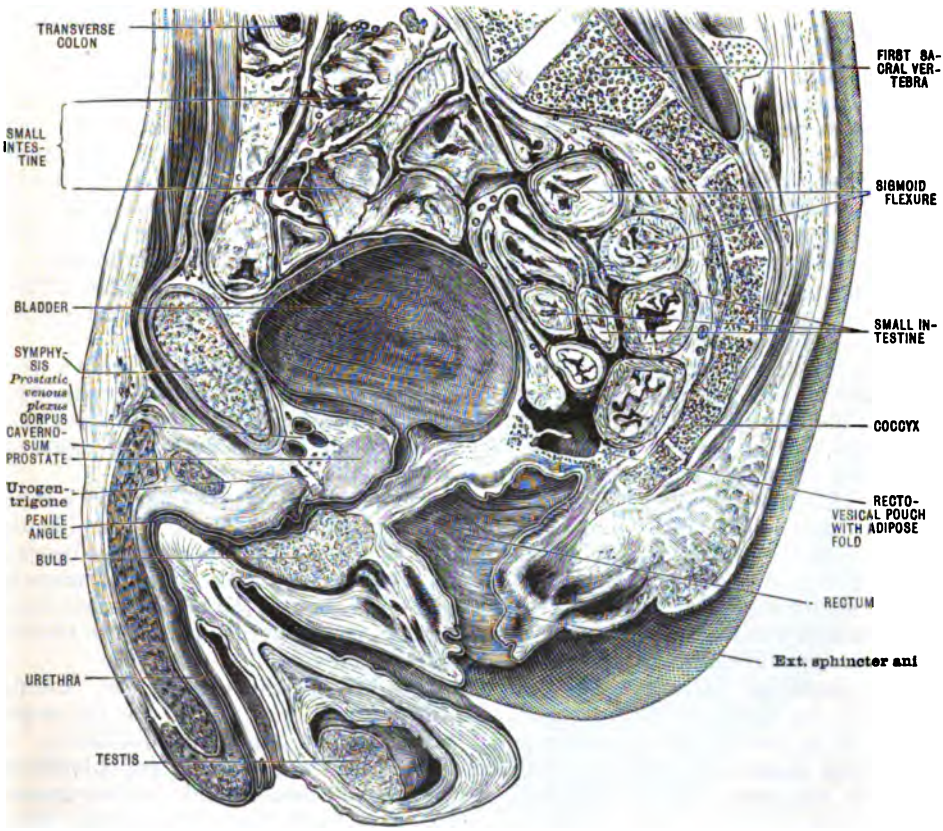
For convenience in description five surfaces may be recognised, but they are but indistinctly separated from each other. One, the **anterior** or **pubic surface,** is directed forwards and downwards; another, the **superior** or **intestinal surface,** looks upwards, the third, the **posterior** or **rectal surface,** looks backwards, and the other two are the **lateral surfaces.** The anterior, superior, and lateral surfaces meet at the **vertex** of the bladder, from which the middle umbilical ligament (urachus) extends to the umbilicus; the posterior surface, sometimes flat and sometimes, especially in old age, convex, forms the floor of what is known as the **fundus;** and the portion of the viscus intervening between the vertex and fundus is termed the **body.** In the center of the line of junction of the anterior and posterior surfaces is the **internal urethral orifice,** by which the bladder communicates with the urethra, and the portion of the organ immediately surrounding this is frequently spoken of as the **neck.**

When the bladder is empty and relaxed, the superior surface sinks down upon the anterior and posterior surfaces, thus becoming concave, and the cavity of the organ is reduced to a T- or Y-shaped fissure.

Relations.—The **anterior surface** looks downwards and forwards towards the symphysis (fig. 861). It is uncovered by peritoneum, but has a strong investment of endopelvic (recto-vesical) fascia, and is separated from the pubic bones and

anterior attachments of the obturatores interni and levatores ani by a space known as the **prævesical space (cavum Retzii)**, which contains a variable quantity of loose fat continuous with the pelvic and abdominal subperitoneal tissue. Each **lateral surface** is covered by peritoneum down to the level of a line extending from the urachus backwards to a point below the summit of the vesiculæ seminales, about 2·5 cm. (1 in.) above the base of the prostate. Below this level it is separated from the levatores ani by subperitoneal tissue, which usually bears much fat in its meshes and ensheathes the vesical vessels and nerves; and it is crossed by the vas deferens, and, at the point of peritoneal reflexion, by the lateral umbilical ligament (obliterated hypogastric artery). The ureter pierces the junction of the posterior and lateral surfaces about 3·5 cm. (1½ in.) above the prostate, the vas passing between it and the vesical wall. External to these structures the lateral wall is in relation to the levator ani and the obturator internus. The **posterior surface** may be divided

FIG. 860.—MEDIAN SAGITTAL SECTION OF THE MALE PELVIS.
(From a preparation in the Museum of St. Thomas's Hospital.)



into two portions, an upper covered by the peritoneum of the recto-vesical or vesico-uterine pouch, a lower in direct contact with the anterior wall of the rectum, and the lower part of the vasa deferentia and vesiculæ seminales. The distance of the recto-vesical *cul-de-sac* of peritoneum from the prostate, situated at the neck of the bladder, is very variable, but usually ranges between 12 and 25 mm. (½ to 1 in.) and may be increased to 5 cm. (2 in.) by distension of the bladder. It is, however, very small in the child. The ureters where they lie at the outer limits of this surface are near to, though not in contact with, the rectum, and a calculus in the lower end of the urinary tube might be felt by exploration from within the bowel. Upon the lower portion of the posterior wall in the male is a **triangular space,** the sides of which are formed by the diverging vasa deferentia, the base by the line of reflexion of the recto-vesical pouch of peritoneum, and the apex by the meeting of the ejaculatory ducts at the summit of the prostate. It was formerly selected as the position

for the introduction of a trocar through the rectum into the bladder in cases of retention of urine. *In the female* the posterior surface is adherent below to the cervix uteri and upper part of the anterior wall of the vagina, but is separated above from the body of the uterus by a shallow vesico-uterine pouch of peritoneum.

The **superior surface** is entirely covered with peritoneum. It looks almost directly upwards into the abdominal cavity, and lies in contact with the small intestines, and sometimes with a portion of the sigmoid colon behind these.

Effects of distension.—When the bladder becomes excessively full it rises above the level of the symphysis, and in certain chronic conditions of retention may even mount as high as the umbilicus. During the process of distension the anterior wall carries upwards the peritoneal folds reflected upon its upper surface from the anterior wall, increasing the prævesical space, and it thus becomes possible to enter the bladder above the pubes without penetrating the peritoneum. This elevation is, however, variable and limited in extent; at its maximum it seldom exceeds 5 cm. (2 in.) and in some instances fails even to pass the upper border of the symphysis. The introduction into the rectum of a bag of suitable dimensions filled with air or water pushes forward the expanded viscus and may still further increase the available space for surgical operation, but it does not ensure the elevation of the peritoneal fold above the symphysis.

The fixation of the bladder.—The arrangement of the **peritoneum** over the superior, lateral, and posterior walls has been described, and it only remains to mention that its reflexions over the urachus above, and from the sides and back of the bladder below, form the superior, lateral, and posterior **false ligaments.** The **endopelvic** (recto-vesical) **fascia** is a well-developed layer of connective tissue over the lower part of the viscus, but is greatly attenuated above. It is continuous below with the capsule of the prostate, and passes to the pubic bones in front of the latter organ in the form of a double fold called the **middle pubo-prostatic (pubo-vesical) ligaments,** and at the sides upon the levatores ani, or rather upon the anterior portion of the tendinous arches from which these pubo-prostatic muscles arise, these reflexions being termed the **lateral (pubo-vesical) ligaments.**

From the apex of the bladder the **middle umbilical ligament** passes upwards to the umbilicus, being formed by the **urachus,** the remains of an embryonic connection between the bladder and the extra-embryonic portion of the allantois; and along each of its sides, though not strictly connected with it, runs a **lateral umbilical ligament** formed by obliterated hypogastric artery.

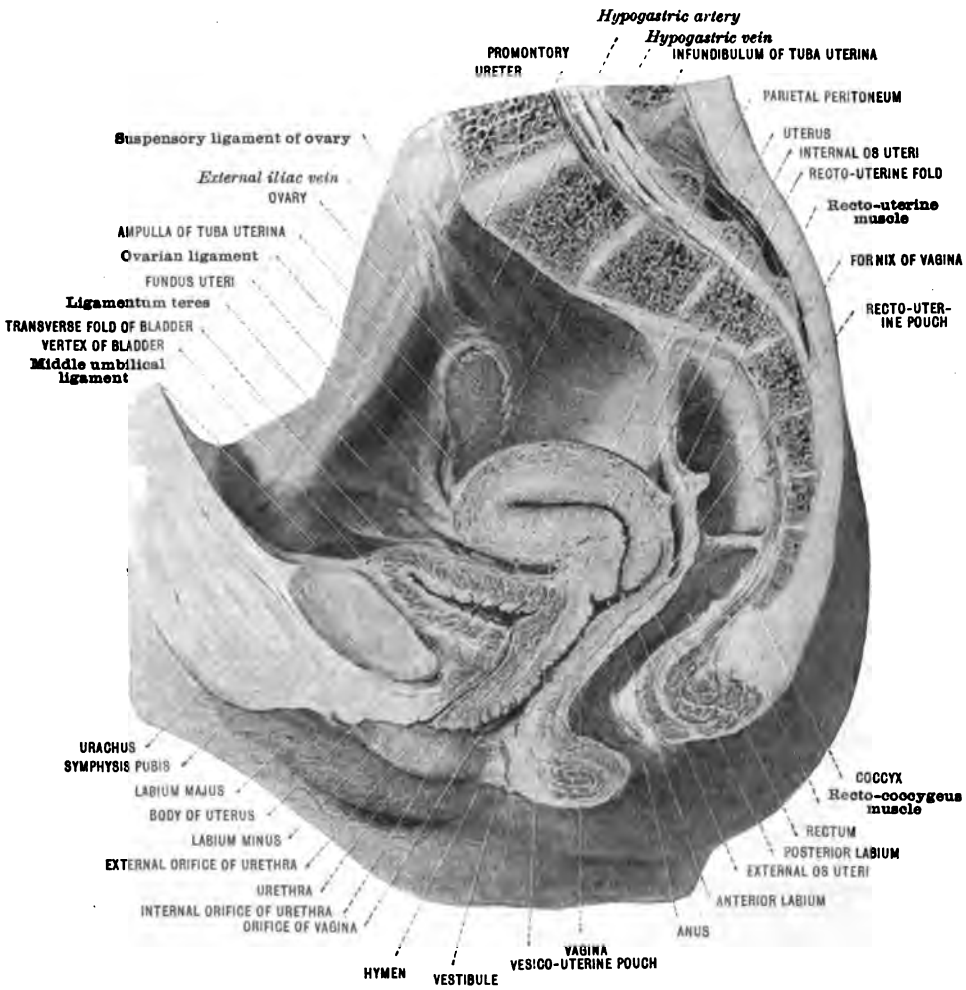
In addition to these ligamentous structures there are certain muscular strands which aid in the fixation. Some of the superficial muscular fibres of the bladder extend from the posterior part of its anterior surface to the pubes, lying beneath the middle pubo-prostatic ligaments and forming the **pubo-vesical muscle,** while other strands pass in the peritoneal folds which bound the recto-vesical pouch (the posterior false ligaments) from the rectum to the posterior wall of the bladder and to the prostate, forming the **recto-vesical muscles.**

The internal surface.—The **mucous membrane** which lines the internal surface of the bladder is smooth, soft, and rose-colored during life. In the empty bladder it is thrown into irregular folds, which become effaced by distension. It is modified posteriorly over a triangular area called the **trigone (of Lieutaud)** (fig. 862), the three angles of which lie at the internal meatus and the two ureteric orifices, and are at a distance from each other of 18 to 25 mm. This region, which lies opposite to the 'second portion' of the rectum, is free from the plication that appears in the rest of the mucous membrane during contraction of the cavity, is bounded by a transverse elevation between the ureters, called the **plica ureterica,** and presents a longitudinal mesial ridge, the **uvula,** near the urethral orifice. It is smaller and less distinct in the female. The **internal urethral orifice** usually lies at the most dependent part of the bladder, but in morbid conditions of the prostate the borders of the aperture may be considerably elevated above the adjacent regions. It is situated in the line of junction of the anterior and posterior surfaces of the bladder, and lies, as a rule, opposite the upper half to the symphysis, but in great distension of the viscus it may descend to a lower level. On the other hand, in young children it usually reaches the level of the upper border of the symphysis, and in old persons with prostatic disease it may rise even above this point. In the male adult it lies 2 to 2·5 cm. behind the symphysis, and about 5 cm. above the perinæum.

Differences due to sex and age.—The **female bladder** (fig. 861) presents no peculiarities of importance, except that its frontal diameter is usually increased at the expense of the sagittal diameter, partly in consequence of the greater width of the pelvis, and partly owing to the presence of the vagina and uterus which encroach upon the space in the middle line. Lateral asymmetry is very common. Furthermore, the symphysis being of less depth than in the male, the urinary orifice lies nearer its lower border.

In the **infant** the bladder is said to be an abdominal organ, but this is not strictly accurate. The relatively small pelvic cavity at this period of life is occupied mainly by the rectum, and there is little room for the bladder, which hence rises into the abdomen even in moderate degrees of distension; but, as pointed out by Symington,

FIG. 861.—SECTION OF THE FEMALE PELVIS. (Spalteholz.)



if a line be drawn from the sacral promontory to the top of the symphysis, fully one-half of the bladder will be found to lie below it, and hence within the pelvis. The internal urethral orifice, however, is behind the upper margin of the symphysis, and the whole organ is hence above the horizontal level of the pubic crests. This relation gradually changes from the period at which independent locomotion begins, till, by the age of six, when the pelvic wall has grown up around the viscus, the position does not differ materially from that in the adult. It should also be noted that the recto-vesical fold of peritoneum extends in infancy nearly as low as the base of the prostate.

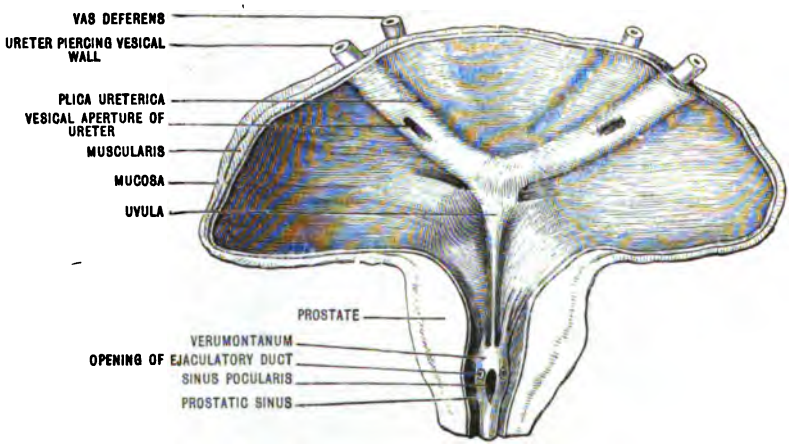
Structure.—The bladder-wall is composed mainly of unstriped muscular fibre, invested externally by a layer of endopelvic (recto-vesical) fascia and a partial covering of peritoneum,

and lined with mucous membrane and submucous tissue. Its thickness varies greatly in different subjects and in the same subject under different conditions of distension. It is estimated at about 3 mm. ($\frac{1}{8}$ in.) when moderately stretched, but may reach 1·2 cm. ($\frac{1}{2}$ in.) or even more when completely contracted. It is somewhat thicker at the trigone.

The **muscular coat** is composed of unstriped fibres, which may be divided roughly into three layers, an outer principally longitudinal, a middle chiefly transverse, and an inner plexiform, but tending towards the vertical direction. The fibres of the *outer layer* are most distinctly longitudinal on the anterior and posterior surfaces, and extend above along the urachus, but they run obliquely over the sides of the bladder, decussating with each other in a complex manner, and near the origin of the urethra, two strong bundles of the anterior longitudinal fibres pass to the pubic bones to form the pubo-vesical muscle. The lower fibres of the middle layer form a kind of annular sphincter near the urethral orifice, the **internal sphincter,** and at the base of the trigone are thickened to form the **plica ureterica.** The *inner layer* appears as a set of well-defined bands running in a longitudinal direction and communicating with each other by means of oblique fasciculi. These bands, when hypertrophied, appear as distinct ridges beneath the mucous membrane, and their interspaces may be seen as depressions which occasionally develop into **diverticular sacculations,** sometimes of considerable size and capable of lodging calculous concretions.

The **submucous coat** consists of a highly elastic connective tissue devoid of muscular fibres. The **mucous coat,** whose epithelium is of the stratified transitional variety, has already been described.

FIG. 862.—THE POSTERIOR WALL OF THE BLADDER. (After Henle.)



Vessels.—The **arteries** of the bladder are usually two in number, the superior and inferior vesical, derived from the hypogastric (internal iliac); branches also pass to the fundus from the middle hæmorrhoidal, and in the female some twigs are also given off by the uterine and vaginal arteries. The **veins** terminate in the internal iliac trunk. They form plexuses which are especially large about the parts adjacent to the prostate, and communicate in the male with all the veins in the neighbourhood. The **lymphatics** appear as a submucous plexus which is most developed in the neighbourhood of the urethral orifice. They accompany the veins and terminate in the hypogastric nodes.

Nerves.—The nerves are derived, partly from the sympathetic system through the hypogastric plexuses, partly from the cerebro-spinal system through the third and fourth sacral nerves.

Development.—In the earlier stages of development the uro-genital ducts and the digestive tract open into a common cavity, the **cloaca,** and from the digestive tract, near its termination, a long tubular outgrowth, the **allantois,** developes, extending through the umbilical cord to the placenta. Later, the cloaca becomes divided in the frontal plane into an anterior portion, the **uro-genital sinus,** into which the allantois and uro-genital ducts open, and a posterior portion, which becomes the lower end of the rectum. The lower portion of the allantois enlarges to form the bladder, and the portion intervening between the enlargement and the umbilicus becomes reduced to a fibrous cord, forming the urachus.

THE MALE REPRODUCTIVE ORGANS

The **reproductive organs of the male** consist of (1) two testes, with their ducts; (2) an organ of copulation, the penis; (3) a musculo-glandular organ, the prostate, which provides a material for the dilution of the semen, and by its

sphincteric contraction aids in the ejaculation of the spermatic fluid, and at the same time intercepts its retrograde passage into the bladder; (4) a pair of bulbo-urethral glands, which empty their secretion into the urethra; and (5) a canal, the urethra, which pierces the prostate and penis, and serves for the transit of both the generative and urinary secretions.

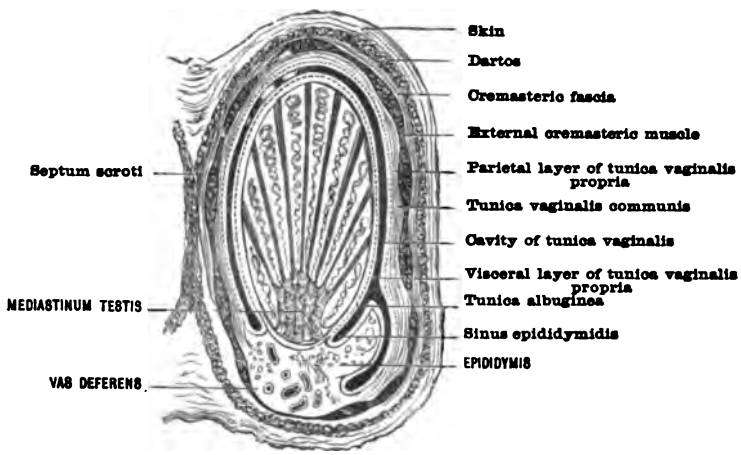
THE TESTES AND THEIR APPENDAGES AND COVERINGS

The two testes lie in a common pouch of integument called the **scrotum,** and each organ is invested in addition by a series of coverings which join in the middle line to form **a septum scroti.** There are five principal layers, named from without inwards; these are:—(1) the tunica dartos; (2) the cremasteric fascia; (3) the external cremaster muscle; (4) the tunica vaginalis communis; and (5) the tunica vaginalis propria.

The Scrotum

The **scrotal integument** (Fig. 863) is more or less pigmented, covered in the adult with coarse, scattered hairs, and provided with strongly developed sebaceous and sudoriparous glands. It presents in the middle line a longitudinal impression, the **raphé,** from which start on either side a multitude of transverse wrinkles, effaceable by distension.

Fig. 863.—Horizontal Section of the Scrotum and Testis. (Diagrammatic.)



(1) The **dartos** is a thin reddish layer composed of elastic tissue freely intermingled with unstriped muscular fibres. It is adherent to the deep surface of the skin, but seems to be a subdermal structure, and is probably equivalent to the superficial fascia of other portions of the body; it is prolonged over the penis and perinæum. Its fibres assume various directions, but for the most part run longitudinally at right angles to the scrotal wrinkles, of which they are the cause. They are always moderately contracted in health, and contract still more under the influence of cold and of mental emotion, but are not affected by electricity. They become relaxed in conditions of general enfeeblement. The more superficial fibres are common to both testes, while the deeper and stronger ones bend inwards at the raphé and assist in the formation of the septum scroti.

(2) The **cremasteric fascia** (external spermatic or intercolumnar fascia, fascia of Cooper) consists of a fatless, laminated connective tissue, within and closely adherent to the dartos, blending at the subcutaneous inguinal (external abdominal) ring with the intercolumnar fibres, and prolonged, like the dartos, over the penis and perinæum. It is continuous behind with the deep layer of the superficial perinæal fascia, and above with the superficial fascia over the symphysis, and it seems to represent in the scrotum the external oblique muscle of the abdomen.

(3) The **external cremaster muscle** (middle spermatic fascia) consists of a

strong double lamina of areolar and elastic tissue enclosing and connecting longitudinal bundles of striped muscle, the fibres of which may be traced above to the external inguinal ring, where they are divided into two principal sets: an inner (often absent), attached to the pubic spine, and an outer derived from the lower border of the internal oblique muscle, and arising from Poupart's ligament opposite the inguinal ring. Below, the layer blends with the dartos opposite the lower extremity of the testis. The cremaster contracts during convulsive expiratory actions of the abdominal muscles and under emotional influences.

(4) The **tunica vaginalis communis** (internal spermatic or infundibuliform fascia) is a delicate connective tissue derived from the fascia transversalis.

(5) The **tunica vaginalis propria** is a serous sac of peritoneal origin, which bears to the testicle a relation similar to that of the serous pericardium of the heart. It consists of parietal and visceral layers. The *parietal layer*, much the thicker of the two, is intimately connected with the tunica vaginalis communis, and consists of elastic fibres, adipose tissue, and a number of non-striped muscular fibres, which are, for the most part, directed longitudinally and form what is termed the **internal cremaster muscle.** Its inner surface is lined with flat pavement epithelium.

The *visceral layer* is intimately adherent to the testis and to the head and outer part of the body of the epididymis, and is prolonged upwards for about 1·2 cm. (½ in.) upon the spermatic cord. On the outer side and above, it extends into a deep depression, the **sinus epididymidis (digital fossa),** between the testicle and epididymis, but it is reflected from the inferior and posterior parts of the testis and from the spermatic cord to become continuous with the parietal layer, thus leaving uncovered nearly the whole of the tail and the internal and posterior surfaces of the epididymis. It is in these uncovered regions that the structures of the cord gain access to the testis and epididymis.

The two layers enclose a serous cavity, but under normal conditions the layers are in contact, the serous fluid being secreted only in sufficient quantity to moisten the opposed surfaces. An undue increase of the fluid constitutes what is known as a vaginal hydrocele.

Vessels and Nerves.—The skin and dartos are supplied by branches of the anterior and posterior scrotal **arteries,** branches, respectively, of the femoral and internal pudic arteries, while the inferior deeper layers receive a special branch from the epigastric; the corresponding **veins** communicate with the long saphenous, the pudic, and the inferior epigastric vein. The **lymphatics** terminate in the innermost set of the inguinal nodes (the lymphatics of the testicle itself passing to the lumbar nodes). The **nerves** are derived from the genito-femoral (genito-crural) and superficial perinæal.

The Testes and Epididymis

The **testes** (fig. 864), two in number, are suspended from the inguinal region by the spermatic cords. The left is supposed to hang somewhat lower than the right in the majority of persons. Each gland consists of two portions, the testis proper and the epididymis. Its weight as a whole averages between 15 and 25 gms.; it is about 4–4·5 cm. (1½ in.) in length, 3 cm. (1¼ in.) in depth (from the anterior to the posterior border), and about 2·2 cm. (⅞ in.) in thickness. It is so suspended in the scrotum that its upper extremity inclines a little more forward than the lower, and its inner surface is turned slightly forwards as well as inwards. It is, however, occasionally rotated so that the epididymis is turned towards the front of the scrotum. The side to which a detached testis belongs may be determined by remembering that the epididymis is attached behind, and that the sinus epididymidis of the tunica vaginalis propria lies on the outer side.

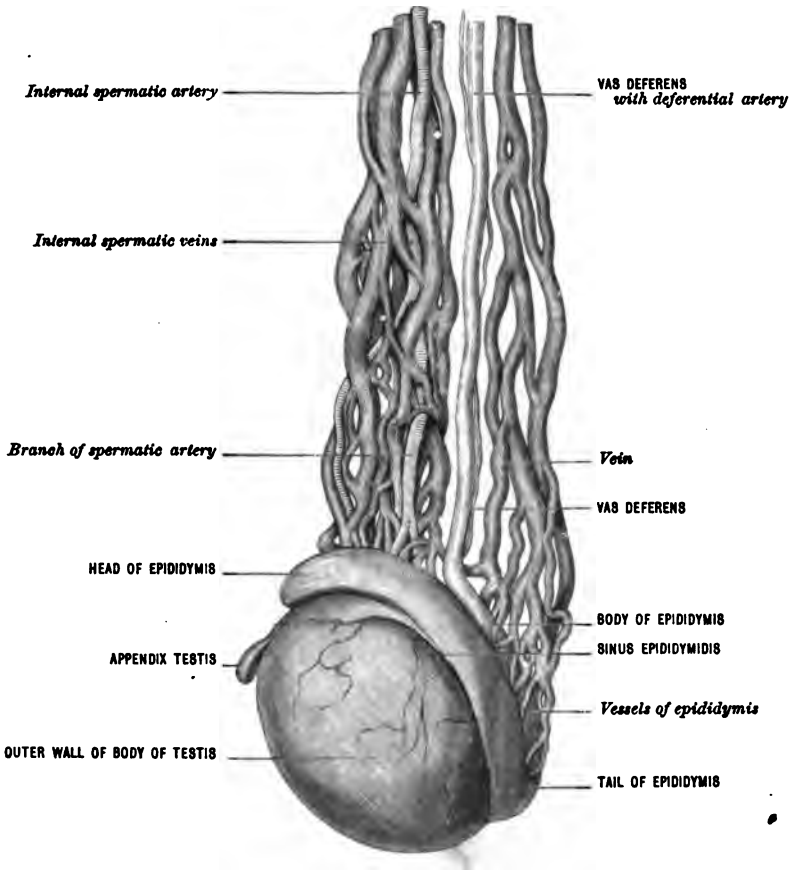
The **testis proper** is shaped somewhat like a kidney bean; it is elongated from above downwards, and flattened from side to side. Its surface is smooth and white, and is covered by the visceral layer of the tunica vaginalis, except where it is in contact with the epididymis.

The **epididymis** is adherent to the posterior and inferior part of the testis proper and inclines slightly to the outer side. It is enlarged above into a **head** or **globus major,** and below into a **tail** or **globus minor,** the intermediate portion being called the **body.**

Structure (fig. 865).—The **testis proper** consists of a tubular parenchyma enclosed within a strong fibrous tunic, the **tunica albuginea.**

The **tunica albuginea** (figs. 863, 865) is a dense, white, inelastic capsule of about 1 mm. ($\frac{1}{25}$ in.) in thickness in the greater part of its extent, but reaching two or three times this thickness beneath the epididymis, where it forms the **mediastinum testis,** or **corpus Highmori.** The **mediastinum** is perforated at its upper and back part by the efferent seminal tubes which go to form the head of the epididymis, and from its inner surface a number of sustentacular processes, in the form of delicate septal planes of connective tissue, the **septulæ,** pass into the interior of the testis. The mediastinum extends forwards from the upper half of the posterior border of the testis, and occupies about a fourth of its sagittal and a third of its transverse diameter; it is tunnelled by blood-vessels and a network of lacunar spaces, the **rete testis,** lined by a low epithelium. The **septulæ** radiate from the deep aspect of the mediastinum to the inner surface of the tunica albuginea, and

FIG. 864.—THE LEFT TESTIS WITH VESSELS AND DUCT. (After Sappey)



subdivide the interior of the capsule into a number (150–200) of loculi, which are wedge shaped, with their bases resting on the tunica albuginea.

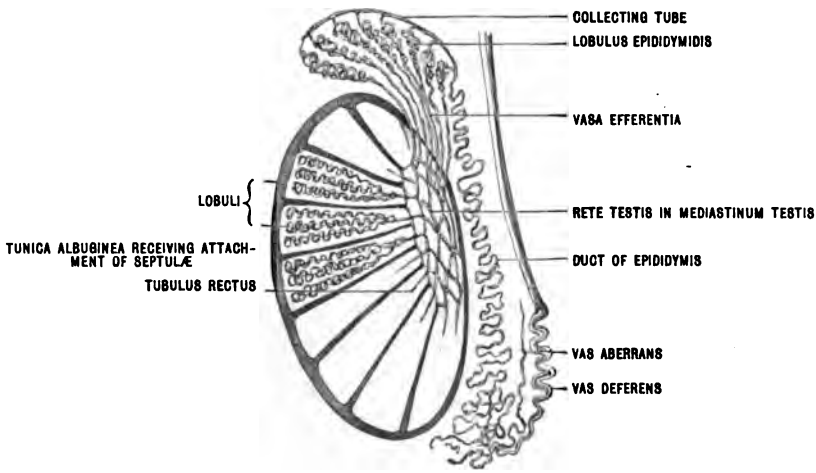
Within these loculi lie the seminiferous tubules, supported by a fine retiform connective tissue, which becomes condensed into a highly vascular lamina called the **tunica vasculosa,** where it is in contact with the albuginea. The **seminiferous tubules** are slender, greatly contorted canals, measuring 0·1–0·2 mm. in diameter, and are lined with a layer of cubical cells from which are developed the **spermatozoa.** The tubules are collected into little bundles, called **lobules,** occupying the loculi, and each comprising three or four separate tubules, so that each testis contains some 500–700 tubules. The tubules of each lobule unite to form a single larger straight tubule, and these **tubuli recti** converge towards the mediastinum, and, on entering it, open into the **rete testis;** from the rete in turn spring twelve to twenty efferent tubes, or **vasa efferentia,** twice or three times as large as the tubules, and these,

piercing the upper and back part of the albuginea, enter the head of the epididymis (fig. 865).

The epididymis is invested by a tunica albuginea continuous with that of the testis proper, but of much greater tenuity. The vasa efferentia, after their escape from the testis proper, form each a tube about six to eight inches in length, lined with ciliated epithelium and coiled in such a manner as to assume the form of a conical mass, the **lobulus epididymidis (conus vasculosus),** with the apex towards the albuginea. The lobuli grouped together constitute the head of the epididymis and their respective tubules open into a single canal, the **duct of the epididymis,** which by its complex coils, fifteen to twenty feet in length, makes up the body and tail of the epididymis, and finally terminates in the **vas deferens.** It presents near its termination one or more diverticula, the largest and most constant of which, the **vas aberrans** of Haller, ranges from 2·5 to 30 cm. (1 to 12 in.) in length, and runs up between the body of the epididymis and the commencement of the vas deferens. The **duct** of the epididymis, like those of the lobuli, is lined with ciliated epithelium, but its walls are thick, and contain two layers of unstriped muscular fibres.

Two little bodies of some morphological interest are to be found appended to the testis proper and the epididymis. The more constant of these, known as the **appendix testis** or **hydatid of Morgagni,** is a pedunculated sac from 3 to 8 mm.

FIG. 865.—DIAGRAM OF THE TESTICULAR TUBULES.



($\frac{1}{8}$ to $\frac{1}{3}$ in.) in length, dilated at its free extremity and containing a clear fluid; it is attached to the upper pole of the testis, usually close to the head of the epididymis. The other, the **appendix epididymidis,** is attached to the head of the epididymis, and is slightly less constant; it has the same general form as the appendix testis, but its peduncle is usually more slender and distinct. Both these structures are believed to correspond to the upper end of the Fallopian tube, and to be a relic of the Müllerian duct (p. 1206), the fœtal structure from which is developed the genital duct of the female.

Another relic, called the **paradidymis,** or **organ of Giraldès,** probably derived from the Wolffian body (p. 1206), is seen in the lowest portion of the spermatic cord immediately above the head of the epididymis. It consists of coiled tubules, blind and dilated at both ends, lying beneath the visceral layer of the funicular portion of the tunica vaginalis. It usually has the appearance of a white or yellowish irregular patch about 5 mm. ($\frac{1}{5}$ in.) in diameter. Any of these embryonic structures may give rise to cystic tumors, and the aberrant tubes are probably not an uncommon source of origin of true spermatic cysts containing seminal fluid.

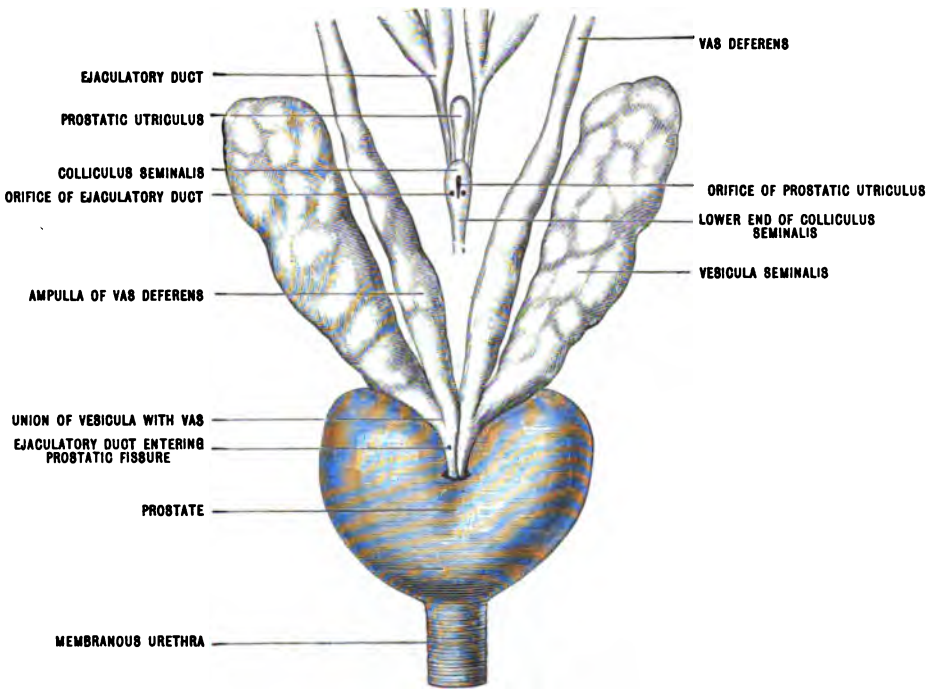
The testis remains small until the period of puberty, and then, together with the penis and prostate, it begins to undergo rapid development; but in some cases its evolution is arrested before it has attained its full dimensions, and this is particu-

larly liable to occur when its descent into the scrotum has been interrupted, or when a varicose dilatation of its veins appears before adolescence. In old age it usually loses much of its functional activity, but this is not invariably the case.

The testis is at first an abdominal organ lying below the kidney and invested by a layer of peritoneum (**mesorchium**) which is firmly adherent to its surface in front and at the sides. It is, moreover, connected by bundles of unstriped muscular fibres, the **gubernaculum testis,** with the pillars of the external inguinal ring and with the dartos at the bottom of the scrotum. It begins to descend in the early part of the third month of fœtal life, reaching the internal inguinal ring in the sixth month. It then passes obliquely through the structures of the abdominal wall, behind a pouch of peritoneum which has preceded it into the scrotum, and pushing before it, in succession, the subperitoneal tissue, an infundibuliform prolongation of the fascia transversalis, a few fibres of the internal oblique (which form part of the external cremaster), and the intercolumnar fascia, which braces together the pillars of the external inguinal ring. At the eighth month it appears at the external ring, and reaches the bottom of the scrotum shortly before birth.

The cause of this migration is still uncertain. The theory usually adopted is that the descent is effected partly by the development of the pelvic and lumbar regions which leave the testicle, fixed by the gubernaculum, behind. This accounts for the change of position to the level of the inguinal canal, but the mechanism of the further descent into the scrotum is unknown.

FIG. 866.—VASA DEFERENTIA AND VESICULÆ SEMINALES. (After Sappey.)



It was formerly attributed to the progressive shortening of the gubernaculum, and, in accordance with this view, the unstriped muscular fibres connecting the bottom of the gland with the scrotum are regarded as the remains of the central and principal gubernacular band, while the lateral bands, ceasing to act after the testis has reached the external ring, are drawn down into the scrotum and appear as scattered groups of fibres, the **internal cremaster** of Henle, lying around the elements of the spermatic cord (fig. 868).

In certain individuals, the descent of one or both testes into the scrotum is interrupted, and cryptorchism results. This condition is normal in certain animals (elephants, cetacea, etc.), but in man is always associated with defective evolution of the organ, and consequent suppression of function.

The peritoneal sac carried with the testis is at first continuous with the abdominal peritoneum. In most cases the tube of communication gradually narrows and at length, within a few days after birth, becomes entirely closed, the sac becoming the tunica vaginalis propria. Sometimes, however, the process of obliteration is more or less incomplete. Should it fail altogether, a portion of the abdominal viscera may pass into the cavity of the tunica vaginalis, and constitute the congenital variety of inguinal hernia; or peritoneal fluid may accumulate in the sac and form a congenital hydrocele. More frequently the continuity of the tunica vaginalis with the peritoneum is interrupted; but a slender pouch of peritoneum, the **processus vaginalis,** may run into the inguinal canal, and even through the external ring into

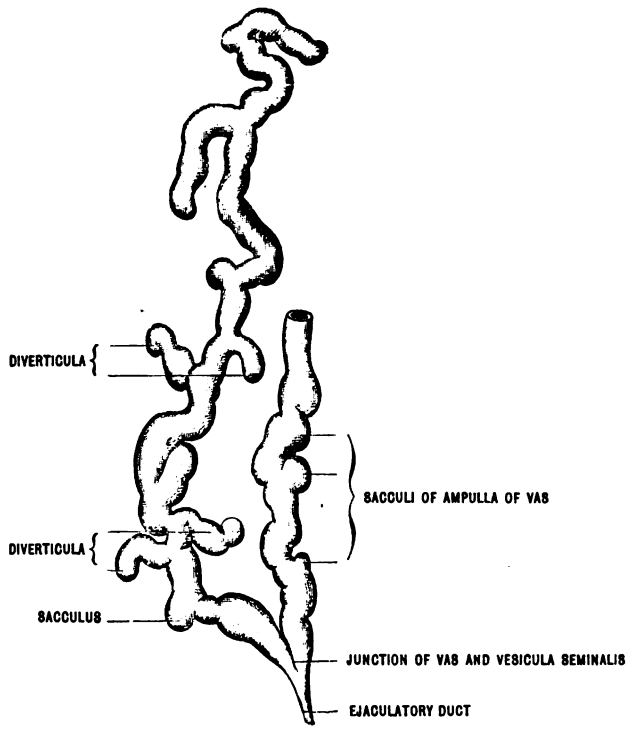
the cord, or the tunica vaginalis may be prolonged upwards upon the cord for a considerable distance.

Should any portion of the abdominal contents enter the processus vaginalis, it may pass through the inguinal canal as a hernia, and descend into the scrotum. If at the same time the upward extension of the tunica vaginalis be present, the hernia with its sac may pass within it or invaginate it, and a surgeon called upon to operate in such a case would probably open the tunica vaginalis before reaching the peritoneal sac, and thus meet with three layers of serous membrane before exposing the extruded intestine. A hernia of this kind is called 'infantile.' Cystic tumors may be formed by the distension of small unobliterated segments of the funicular portion of the tube, and are called encysted hydroceles of the cord.

The Vas Deferens

The **vas deferens** is the continuation of the tube of the epididymis, and extends from the tail of the epididymis to the prostatic portion of the urethra. In the lower part of its course it is slender and tortuous, but it becomes thicker and straighter as it ascends along the back of the epididymis (**testicular portion**), and attains its full size before it reaches the top of the organ. From this point it is the principal element of the spermatic cord, and runs upwards almost vertically as far as the external inguinal ring (**funicular portion**); entering the inguinal canal, it runs obliquely outwards, upwards, and slightly backwards to the internal ring (**inguinal portion**). It then leaves the associated vessels of the cord, and, winding around the origin

Fig. 867.—Vas Deferens and Vesicula Seminalis dissected. (After Sappey.)



of the inferior epigastric artery to the inner side of the external iliac artery and in front of the external iliac vein, enters the pelvis (**pelvic portion**) close to the iliopubic suture, and runs downwards and backwards over the side of the bladder, crossing it on the vesical side of the obliterated hypogastric artery and ureter, to reach the side of the posterior wall of the viscus. Here it lies between the bladder and the rectum, and, becoming enlarged and sacculated, passes downwards and inwards towards the base of the prostate, where it narrows and is joined by the lower end of the vesicula seminalis. The common tube thus formed descends as the **ejaculatory duct,** to pierce the prostatic fissure and open into the prostatic portion of the urethra. The two vasa deferentia, where they lie in front of the

rectum, are separated by a triangular interval, the apex of which is formed by the approximation of the ejaculatory ducts, and lies immediately above the prostate. The whole of the pelvic portion of the vas is subperitoneal except near its termination, where it is invested only by the endopelvic (recto-vesical) fascia and an extension of subperitoneal tissue.

The entire length of the vas deferens is 40–45 cm. (about 16 in.), of which 3 cm. (1¼ in.) may be allotted to the testicular portion, about 7·5 cm. (3 in.) to the funicular portion, 4·5 cm. (1¾ in.) to the inguinal portion, and the rest to the pelvic portion. It is cylindrical and of uniform diameter—2–3 mm. (⅛ in.)—in its funicular, inguinal, and pelvic stages down to the retrovesical portion, and its walls are of great thickness, about 1 mm., while its calibre is extremely small. It is here composed of an outer adventitia containing vessels and smooth muscular fibres, a threefold muscular coat with external and internal longitudinal and middle circular layers, and a mucous membrane lined with cylindrical epithelium. The retrovesical portion differs from the rest in that it gradually increases in size until it reaches twice its original diameter, its wall at the same time becoming thinner and sacculated. This enlarged portion is the **ampulla** of the vas deferens, and it approximates in appearance the seminal vesicles (fig. 867).

THE SEMINAL VESICLES

The **vesiculæ seminales** (figs. 866 and 867) are two diverticular reservoirs situated between the bladder and rectum, external to the ampullæ of the vasa deferentia.

Each vesicle is of somewhat triangular form, its broad upper extremity lying beneath the peritoneum, its apex joining the vas deferens at the base of the prostate. It averages about 6 cm. (2¼ in.) in length and 1·2 cm. (½ in.) in diameter at its base. It is lobulated on the surface, and on dissection is found to consist of a central tube 8 to 12 cm. (3 to 5 in.) in length, with usually several short lateral branches. It is related *in front* to the posterior wall of the bladder, and by its upper extremity overlaps the ureter; *posteriorly* it is covered by the recto-vesical pouch of peritoneum, for a short distance above; and below this point it lies in direct contact with the front of the rectum, and external to the ampulla of the vas deferens. It becomes constricted at its junction with the vas. Structurally it consists of a fibrous external coat, a middle muscular coat, and an internal mucous membrane. The muscularis is arranged in three layers, the inner and outer of which are longitudinal in direction, the intermediate fibres being transverse.

The mucous membrane is plicated, sacculated, yellowish-brown in colour, and lined with cylindrical epithelium. The entire vesicle is invested, together with the ampulla of the vas, by a sheath of fibrous tissue, continuous below with the capsule of the prostate, above with the subperitoneal tissue, and containing numerous smooth muscular fibres.

THE EJACULATORY DUCT

The **ejaculatory duct,** formed on each side by the union of the vas deferens and vesicula seminalis, is an infundibuliform tube 16–19 mm. (¾ in.) in length, and about 3 mm. (⅛ in.) in width above, narrowing to one-third that size below, while the lumen near its opening is not more than 0·2 mm. in diameter. In the upper part of its course each duct possesses a number (4 or 5) of diverticula. The two ducts converge slightly as they descend, and finally, passing behind the so-called 'middle lobe,' the hinder part of the basal muscular ring of the prostate (p. 1186), pierce the prostatic fissure and open upon the colliculus seminalis (verumontanum) on either side of the orifice of the prostatic utriculus (sinus pocularis) (fig. 872).

Vessels and nerves of the testis and its appendages.—The testis is supplied with blood by the internal spermatic and deferential **arteries,** the two vessels anastomosing with each other and with the scrotal arteries at the lower extremity of the organ. The corresponding **veins,** internal spermatic and deferential, form like communications, and run up in two separate groups. The spermatic veins, large, numerous and imperfectly valved, spring from the upper part of the testicle, and form an extensive plexus, the **pampiniform plexus,** which finally becomes reduced to a single stem at the internal inguinal ring. The **lymphatics of the vas** and

testis accompany the veins. The former terminate in the pelvic iliac glands, the latter in the lumbar glands.

The free anastomosis between the deferential, spermatic, and scrotal blood-vessels explains why the ligature or incision of the spermatic veins and artery in varicocele leaves the nutrition of the testicle unimpaired; while the intercommunication of the testicular and scrotal blood and lymph vessels behind the epididymis accounts for the extension of inflammatory affections of the epididymis to the scrotal integument.

The **nerves** of the testis come from the aortic, renal, and hypogastric plexuses.

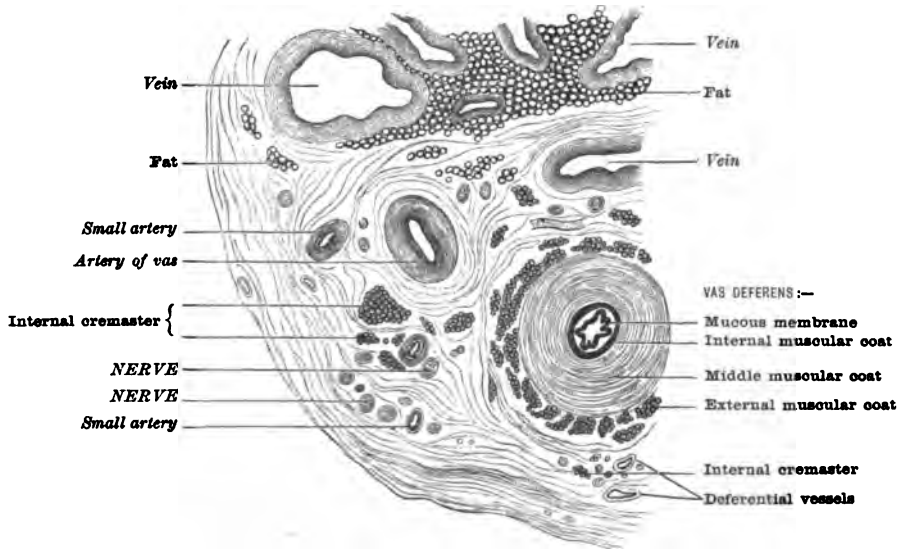
The vesicula seminalis is supplied by the deferential, inferior vesical, and middle hæmorrhoidal **arteries**: its veins, large and numerous, form a kind of plexus which receives some of the vesical veins, and communicates below and in front with the prostatic plexus: its **lymphatics** end in the hypogastric nodes, and the **nerves** are derived from the hypogastric plexus.

SPERMATIC CORD

The **spermatic cord** is the elongated pedicle of the testis. It extends from the internal inguinal ring, where its component structures are collected together, through the inguinal canal, and into the scrotum as far as the summit of the testis. Its constituent elements are as follow (fig. 868):—

1. The **vas deferens,** lying with the deferential vessels posterior to the other structures, and recognisable by its cord-like resistance to pressure.
2. The **spermatic artery.**
3. The **spermatic veins,** or pampiniform plexus, surrounding the artery.
4. **Lymphatics** running with the veins.
5. **Sympathetic nerves** accompanying the artery.

FIG. 868.—SECTION OF THE SPERMATIC CORD (After Henle.)



6. The **processus vaginalis,** occasionally seen as a thread-like relic of the tube of communication between the tunica vaginalis and peritoneum. It is frequently patent for a short distance near the internal inguinal ring, and probably accounts in great part for the insidious development of hernial protrusions in this region.

These structures, together with a considerable quantity of fat and connective tissue, as well as scattered bundles of unstriated muscular tissue, which represent the funicular portions of the **internal cremaster muscle,** are enclosed within an investment, corresponding essentially to that of the testis. Externally there is a layer of connective tissue, the **cremasteric fascia,** continuous at the external inguinal ring with the intercolumnar fibres and the fascia of the external oblique

muscle; within this is the **external cremaster muscle,** especially developed in the posterior surface of the cord and continuous above with the internal oblique muscle; and within this the **tunica vaginalis communis,** representing the transversalis fascia of the abdomen.

THE PENIS

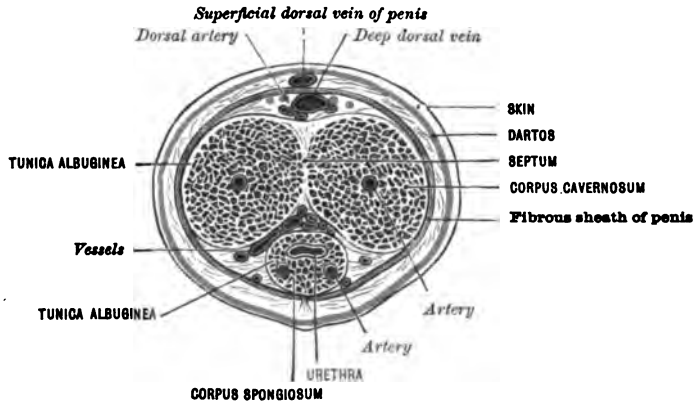
The **penis** is composed of three rod-like segments of erectile tissue, firmly united together and invested by a sheath composed of integument, dartos, and fascia (fig. 869).

Of these three erectile segments, two, the **corpora cavernosa penis,** are placed side by side above or dorsally; the third, the **corpus cavernosum urethræ** or **corpus spongiosum,** is perforated in its whole length by the urethral canal, and lies on the ventral aspect of the former, except where it expands distally to form the free end of the organ (fig. 870).

The penis as a whole may be divided into a root, a body, and a terminal enlargement or glans; the **root** is attached to the symphysis and pubic arch; the **body,** prismatic, with rounded angles in section, forms the greater part of the free portion of the organ; and the **glans** is a heart-shaped expansion, more developed on its dorsal than on its ventral aspect, and presenting the external urethral orifice at its distal extremity. The body and glans are separated by a constriction called the **neck.**

The **coverings of the penis** are continuous with those of the testis. The **skin,** like that of the scrotum, is pigmented and highly elastic, and unlike the skin over the rest of the body, is devoid of smooth muscular fibres and subcutaneous fat. It

FIG. 869.—TRANSVERSE SECTION THROUGH THE BODY OF THE PENIS.



contains sudoriparous and sebaceous glands, the latter being especially abundant and large on the urethral surface. The **dartos,** situated immediately beneath the corium, is continuous with the dartos tissue (p. 1175) of the scrotum, and consists of smooth muscle, the fibres of which are for the most part disposed longitudinally. Beneath the dartos is a loose elastic **connective-tissue layer** containing the superficial vessels and nerves of the penis, and very liable to infiltration in inflammatory or dropsical conditions and in urinary extravasation. Beneath this lies the **fascia penis,** a complete and highly elastic tunic, continuous with the superficial fascia of the perinæum and of the inguinal region, and investing the entire organ as far as the base of the glans, where it fuses with the integument. It is also adherent both to the skin and to the corpus spongiosum along the ventral raphé, and it covers the deep dorsal vessels and nerves and the lateral tributaries which converge to the dorsal vein. This sheath, aided by the dartos and certain processes from the bulbo-cavernosi and ischio-cavernosi muscles, compresses the veins of the penis.

At the neck of the penis the skin and dartos form a free fold, the **prepuce,** which more or less completely encloses the glans. The fold gradually diminishes in depth from the dorsal mid-line ventrally, and in the ventral mid-line is connected to the

glans, just behind the urethral orifice, by a small fold, the **frenulum**; this contains vessels of some size, so that considerable hæmorrhage may result from its rupture.

The preputial orifice is usually large enough to allow the easy retraction of the fold, but sometimes is congenitally constricted, and prevents the exposure of the glans (phimosis). Owing to the composition of the prepuce by two layers of integument, the removal of a complete ring as in the ordinary operation for phimosis impedes the passage of the lymph and blood from the portion left attached to the glans, and hence considerable infiltration of this part may result. The epithelium of the inner surface of the prepuce is sometimes spoken of as a 'mucous membrane,' and it resembles such a membrane in the absence of hairs and sudoriparous glands. The cells cast off from its surface, mingled with micro-organisms which normally occur within the preputial space, form a white, odoriferous substance, the **smegma præputialis.**

The integument of the glans is continuous with that of the inner surface of the prepuce at the neck of the penis, and with the mucous membrane of the urethra at the urethral orifice. It is intimately connected with the subjacent tissue, and, therefore, not movable, like that of the body of the penis.

The **suspensory ligament** of the penis is a strong band of fibrous tissue which passes from the front of the symphysis to the subjacent portion of the organ, blending with the fascia of the penis in the middle line and at the sides, and being continued into the septum scroti below. A second ligament, the **fundiform ligament,** also suspensory in function, passes to the penis from the lower part of the linea alba. It contains elastic tissue, and at its attachment to the penis divides into two portions, between which pass the dorsal vessels and nerves. The **angle of the penis** corresponds to the most anterior point of suspension to the symphysis.

The **corpora cavernosa penis** constitute the dorsal and larger part of the penis. They are closely united in the greater part of their extent, but separate a short distance in front and diverge somewhat widely behind. The posterior extremity of each, called the **crus penis,** at first enlarges slightly, but tapers as it approaches the subpubic arch; then, becoming tendinous and somewhat flattened, it is strongly attached to the ischio-pubic rami; and the distal end, pointed somewhat like the tip of a cigar, is plunged into the substance of the glans (fig. 870). The entire length of the corpus cavernosum penis averages about 15 cm. (6 in.), and its breadth about 1·2 cm. ($\frac{1}{2}$ in.), but it increases in size by one-third or more when its vascular spaces are fully distended.

In structure it consists of a sponge-like erectile tissue invested by a strong sheath or **tunica albuginea.** This sheath is about 2 mm. ($\frac{1}{12}$ in.) in thickness, white, remarkably tough, and consists of two laminæ, an external, of longitudinal fibres common to both corpora cavernosa; and an internal, of circular fibres surrounding each corpus and forming a mesial **septum** where the two corpora cavernosa come into contact. The framework of the cavernous structure is formed by a reticular arrangement of fibro-muscular trabecular bands, starting from the inner surface of the albuginea and becoming more slender as they approach the axis of the body. The branches of the supplying artery run in the trabeculæ and terminate by opening into the anastomosing intertrabecular spaces which represent the widely dilated capillaries of the organ.

The **corpus cavernosum urethræ** or **corpus spongiosum** lies in the middle line and below the united corpora cavernosa penis. Unlike the latter it has no direct attachment to the pelvic bones, but terminates at each end in a bulbous expansion. It may be divided into a glans, a body, and a bulb.

The anterior enlargement, or **glans,** is somewhat heart-shaped, its base extending much farther over the dorsal than over the ventral aspect of the corpora cavernosa, and showing a distinct indication of division into two lateral lobes in the latter situation. The most prominent part of the base is called the **corona glandis,** and the groove behind this is the **neck** of the penis or balano-preputial furrow. At its tip the glans presents a vertical fissure about one-third of an inch in length, the **external urethral orifice.**

The glans is composed of erectile tissue with coarse trabeculæ, and is covered with a firmly adherent layer of skin continuous with the inner layer of the prepuce. Its capacity for vascular engorgement is much less than that of the corpus cavernosum penis or the rest of the corpus spongiosum, and it does not attain a like degree of hardness during erection.

The **body** of the corpus spongiosum is cylindrical, uniform in diameter, and is traversed axially in its whole length by the urethra; it is lodged above in a groove between the two corpora cavernosa, while its ventral aspect is subcutaneous except where it corresponds to the attachment of the scrotum. Structurally it is provided with a thin albuginea, between which and the urethra lies a narrow layer of erectile tissue.

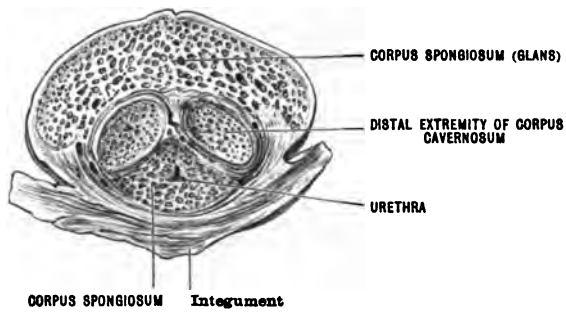
The **bulb** is formed by an expansion of the erectile structure, and the portion of the urethra by which it is traversed undergoes a well-marked dilatation, and lies nearer its upper than its lower surface. It is about 3·7 cm. (1½ in.) in length, and its greatest width is about 1·8 cm. (¾ in.). It is surrounded by the bulbo-cavernosi muscles, the greater part of the fibres of which pass between it and the corpora cavernosa to blend together in the middle line; and it rests posteriorly against the superficial layer of the urogenital trigone (triangular ligament) about 1·3 cm. (½ in.) in front of the anus. It is liable to considerable enlargement after middle age.

Muscles.—The muscles of the penis are three on each side—the ischio-cavernosus, the bulbo-cavernosus, and the superficial transversus perinæi. They will be described in connection with the perinæum.

Vessels and Nerves of the Penis.

Artery.—The envelopes of the penis are supplied by the external pudic, the superficial perinæal, and the dorsal artery; the first from the femoral, the others from the internal pudic. The corpora cavernosa penis are supplied by the deep artery of the penis; the corpus spongiosum by the special artery of the bulb (internal pudic) and the dorsal artery.

FIG. 870.—TRANSVERSE SECTION OF THE PENIS THROUGH THE BASE OF THE GLANS.



Veins.—The veins of the coverings of the penis end in one or two superficial dorsal veins which run in the connective tissue layer between the dartos and fascial sheath, and end in the long saphenous and femoral veins. The deep veins of the corpora cavernosa penis and corpus spongiosum terminate partly in the pudendal plexus (chiefly through the deep dorsal vein), and partly in the internal pudic. They communicate freely with each other and with the superficial veins.

Lymphatics.—The lymphatics run with the veins, those of the coverings being collected by superficial dorsal trunks which pass to the inguinal nodes. The deep lymphatics from the corpora cavernosa penis and corpus spongiosum for the most part join a dorsal cord which runs with the deep dorsal vein to end in the inguinal nodes; a few probably reach the hypogastric and lumbar nodes.

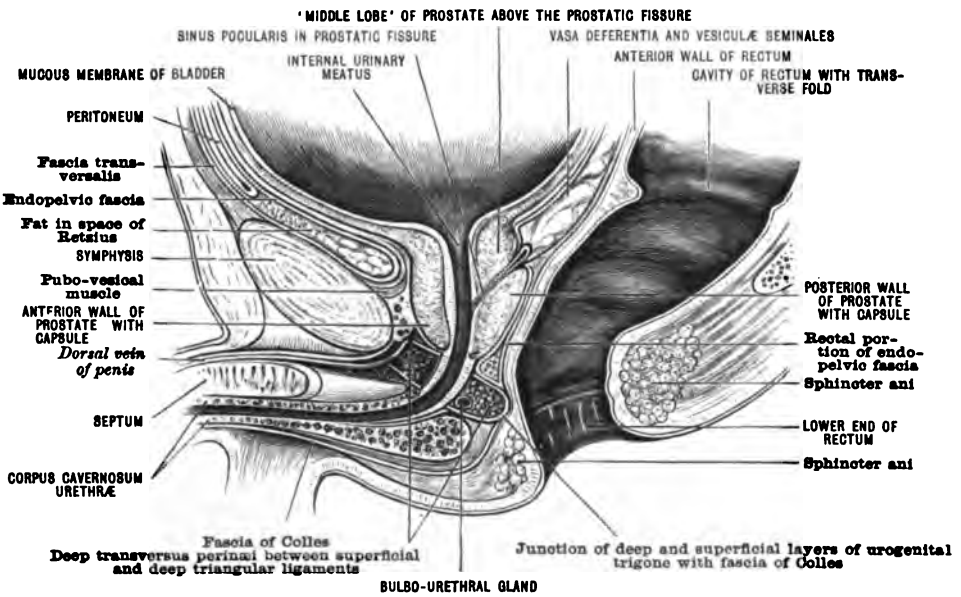
Nerves.—The integumentary structures are supplied by the inguinal branch of the ilio-inguinal and the superficial perinæal branches of the pudic. The erectile bodies receive filaments from the dorsal nerve of the penis, the superficial perinæal, and the prostatic plexus. This last is a derivative of the hypogastric plexus, and to it fibres pass directly from the third and fourth sacral nerves; these constitute the **nervus erigens** (Eckhard), stimulation of which produces dilation of the arteries of the corpora cavernosa.

THE PROSTATE

The **prostate** is a firm elastic and contractile organ, lying between the bladder and the penis, and perforated by the urethra (figs. 866, 871, and 872). It is roughly comparable to a horse-chestnut in form and dimensions; its broader extremity or

base lies uppermost and blends with the vesical sphincter, while its apex rests against the uro-genital diaphragm (triangular ligament). Its long axis is vertical (in the erect posture) or inclines slightly forwards below (fig. 871), and is nearly 3 cm. (1¼ in.) in length. Its transverse diameter, greatest near the base, measures about 4 cm. (1½ in.), and its antero-posterior diameter about 2·5 cm. (1 in.). Its usual weight is from 20 to 25 gm., nearly the same as that of the testis, and it may be noted that the active evolution of the two organs begins at the same period, at puberty, and that the structural and functional development of the one is intimately associated with that of the other during the period of sexual vigor. It offers for description a base, an apex, and anterior, lateral, and posterior walls. The **base** is connected with the musculature of the bladder, receiving the attachment of the longitudinal fibres and surrounding the sphincteric portion of the circular layer at the urethral orifice. It usually lies a little above the level of the middle of the symphysis. The **apex,** resting against the urogenital diaphragm, is from 12 to 18 mm. (½ to ¾ in.) behind and a little below the subpubic angle, and on rectal exploration will be found about 3 or 4 cm. (1½ in.) above the margin of the anus. The **anterior wall** is rounded, and is covered by the prostatic plexus of veins and the pubo-vesical muscles and pubo-prostatic ligaments (p. 1172). The **lateral walls** are in contact

FIG. 871.—SEMI-DIAGRAMMATIC SECTION OF THE MALE PELVIS.



with the inner borders of the two levatores ani muscles and the marginal portion of the venous plexus, and project above and behind in the form of ill-defined **lateral lobes,** which may be looked upon as the persistent indication of its development in two halves. The **posterior wall** is flattened and is opposed to the rectum, from which it is separated by some connective tissue and unstriped muscular fibres continuous with the subperitoneal tissue and pelvic fascia. Near its upper border is a transverse median cleft, the **prostatic fissure** (fig. 866), which extends deeply inwards and forwards towards the middle of the prostatic urethra, transmitting the common ejaculatory ducts and the prostatic utriculus (sinus pocularis), and in section (fig. 871) appearing as the posterior and inferior boundary of a portion of the substance of the organ, the so-called **'middle lobe.'**

An irregular artery, usually derived from the hypogastric trunk, is sometimes found running by the side of the prostate to reach the dorsum of the penis, and may be the source of dangerous hæmorrhage in lateral lithotomy. It replaces one or more of the terminal branches of the internal pudic.

Structure and function.—The prostate is invested by a fibro-muscular capsule, derived from the endopelvic (recto-vesical) segment of the pelvic fascia, unstriped

muscle existing in largest proportion over its rectal aspect, between the opposed borders of the levatores ani. The organ itself is composed of muscular and glandular tissue. The muscular element, comprising both striped and unstriped fibres, represents about one-half of the entire mass. The unstriped fibres embrace the vesical sphincter above, forming with this a ring of great firmness and strength above the urethral orifices of the ejaculatory ducts, and discharging in all probability the function of intercepting the backward flow of the semen and prostatic fluid into the bladder during sexual congress; below this point, the muscle is intermingled with gland tissue and striated fibres. The striped fibres lie chiefly in the anterior wall of the prostate, but completely encircle the apex of the organ, and are there probably connected with the deep transversus perinæi. The muscular fibres of both kinds below the ejaculatory ducts undoubtedly initiate the forward propulsion of the mingled prostatic and seminal secretions; the ejaculation being further aided by the contraction of the deep transversus perinæi, and bulbo-cavernosi.

The glands are of the branched tubular type, and lie chiefly in the posterior and lateral parts of the organ, their ducts opening into the urethral recesses (**prostatic sinuses**) by the sides of the colliculus seminalis (verumontanum). They secrete a mucus, the principal use of which is to dilute and give bulk to the semen, and they are sometimes the seat of pathological concretions. In addition to the true glands are seen a number of simple follicles in the anterior wall of the prostatic urethra, probably of the same nature as the rest of the urethral follicles. The prostatic urethra will be described hereafter (page 1188).

The organ is essentially generative, but serves also to reinforce the vesical sphincter, although its imperfect development in the female and in children and eunuchs appears to entail no defect in the control of the bladder. It is represented in the female by some poorly developed glands which open into the terminal portion of the urethra. Its glandular elements secrete a milky fluid, alkaline in reaction and rich in proteid material, which serves to dilute the seminal fluid and stimulates the spermatozoa to active movement.

Vessels and nerves.—The **arteries** of the prostate arise from the adjacent vesical and hæmorrhoidal arteries. The **veins** receive the dorsal vein of the penis, and after forming a plexus (the **pudendal plexus** or **plexus of Santorini**), investing the anterior and a portion of the lateral surfaces, terminate in the adjacent vesical veins. The **lymphatics** end in the hypogastric nodes, and a small node may sometimes be found on each side near the base of the organ. The **nerves** are derived from the hypogastric plexus.

The Bulbo-urethral (Cowper's) Glands

The **bulbo-urethral glands,** also known as the **glands of Cowper,** are two in number, and are imbedded in the sphincter of the membranous urethra, between the two layers of the urogenital trigone. They lie on either side of the membranous portion of the urethra, above the posterior portion of the bulb, and are of a whitish colour, measure from 4 to 9 mm. ($\frac{1}{6}$ to $\frac{1}{3}$ in.) in diameter, and have a slightly tuberculated surface. Each is a compound alveolo-tubular gland, whose duct pierces the inferior fascia of the urogenital trigone, enters the substance of the bulb, and, after a total course of about 3 or 4 cm. ($1\frac{1}{4}$ to $1\frac{1}{2}$ in.), terminates by opening upon the ventral surface of the cavernous portion of the urethra.

The glands produce an alkaline, glairy secretion, whose function may be to neutralise any acidity of the urethra which might inhibit the activity of the spermatozoa.

THE MALE URETHRA

The **urethra** is the mucous canal extending from the bladder to the extremity of the glans penis. In its course it pierces the prostate from base to apex, the urogenital trigone, and the whole length of the corpus cavernosum urethræ. It may hence be divided into three segments:—(1) Prostatic; (2) membranous (the portion lying in the space between the two layers of the urogenital trigone); and (3) cavernous or spongy (fig. 872).

The **prostatic portion** runs almost vertically downwards from the internal urethral orifice, but with a slight forward inclination below; the **membranous**

portion and the posterior part of the **cavernous portion** as far as the anterior border of the suspensory ligament of the penis describe a curve beneath the symphysis; lastly, the portion of the cavernous urethra, beyond the penile angle, follows the direction of the pendent portion of the penis and necessarily follows the movements of that organ. The urethra has, accordingly, a somewhat ∽-shaped course.

Its average length is still variously stated by different authorities, but, according to the observations of Waldeyer, the distance from the internal to the external orifice is from 18 to 20 cm. (7 to 8 in.), reaching in some cases 24 cm. (9½ in.), or being reduced in others to 14 cm. (5½ in.). Of this length, about 2·5 to 3 cm. (1 to 1¼ in.) are occupied by the prostatic portion, and 1·0 or 1·2 cm. (½ in.) by the membranous portion. The canal may be greatly lengthened by senile hypertrophy of the prostate, which carries the internal meatus upwards towards the level of the top of the symphysis.

The diameters of the canal vary considerably at different points, and can be only approximately determined. In the relaxed condition the lumen has the form of a slit, but when moderately distended, four dilatations and as many constrictions can be recognised in it. Starting with the constriction at the internal urethral orifice, the urethra widens up to about the middle of its prostatic portion, where its diameter is about 15 mm. (⅝ in.); it then diminishes to the junction of the membranous and cavernous portions, where the diameter falls to 4·5 mm. ($\frac{3}{16}$ in.), this being the narrowest portion of the canal. In the bulb it dilates to a diameter of 12 mm. (½ in.), and throughout the cavernous portion it averages about 10 mm. (⅖ in.), diminishing as it reaches the glans to about 9 mm. (⅜ in.); in the glans it dilates again, forming the **fossa navicularis,** with a diameter of from 12 to 15 mm. (½ to ⅝ in.), and, finally, at the external orifice, it is again reduced to 7 or 8 mm. (¼ or ⅓ in.).

In all parts of its course, however, it is capable of considerable distension, the external orifice falling behind the other portions in this respect. This is capable of distension to 8 or 10 mm. (⅓ or ⅖ in.), and then follow, in the order of their distensibility, the membranous portion, the cavernous portion, the prostatic portion, the bulbous portion, and, lastly, the internal orifice, which may be distended to 20 mm.

The **prostatic portion** is about 3 cm. (1¼ in.) in length, wider in the middle than at the two extremities, and almost perpendicular in direction, with a slight inclination downwards and forwards at its lower end. Its anterior wall is concave both in longitudinal and transverse sections, and is studded with the orifices of small mucous follicles; the posterior wall presents a longitudinal ridge called the **colliculus seminalis** or **verumontanum,** highest near the middle and gradually diminishing above and below. A little above the centre of the colliculus may be seen a rather large opening which leads to a *cul-de-sac* of especial interest for the morphologist, the **prostatic utriculus (sinus pocularis or uterus masculinus),** and on the lateral margins of the orifice of the utriculus are seen two small puncta, one on each side, the openings of the **ejaculatory ducts.** The utriculus and ducts may be traced upwards and backwards through the prostatic cleft and behind the sphincteric fibres which constitute the middle lobe of the prostate.

In consequence of the presence of the colliculus the urethral fissure appears on horizontal section as a U-shaped curve with forward convexity. The recesses corresponding to the extremities of the U are sometimes called the **prostatic sinuses,** and into these open the orifices of the prostatic ducts.

The *mucous membrane* of the prostatic urethra is lined with a laminated epithelium. Beneath this is a layer of erectile tissue which constitutes the principal element of the colliculus, and is in turn supported by a layer of longitudinal muscle.

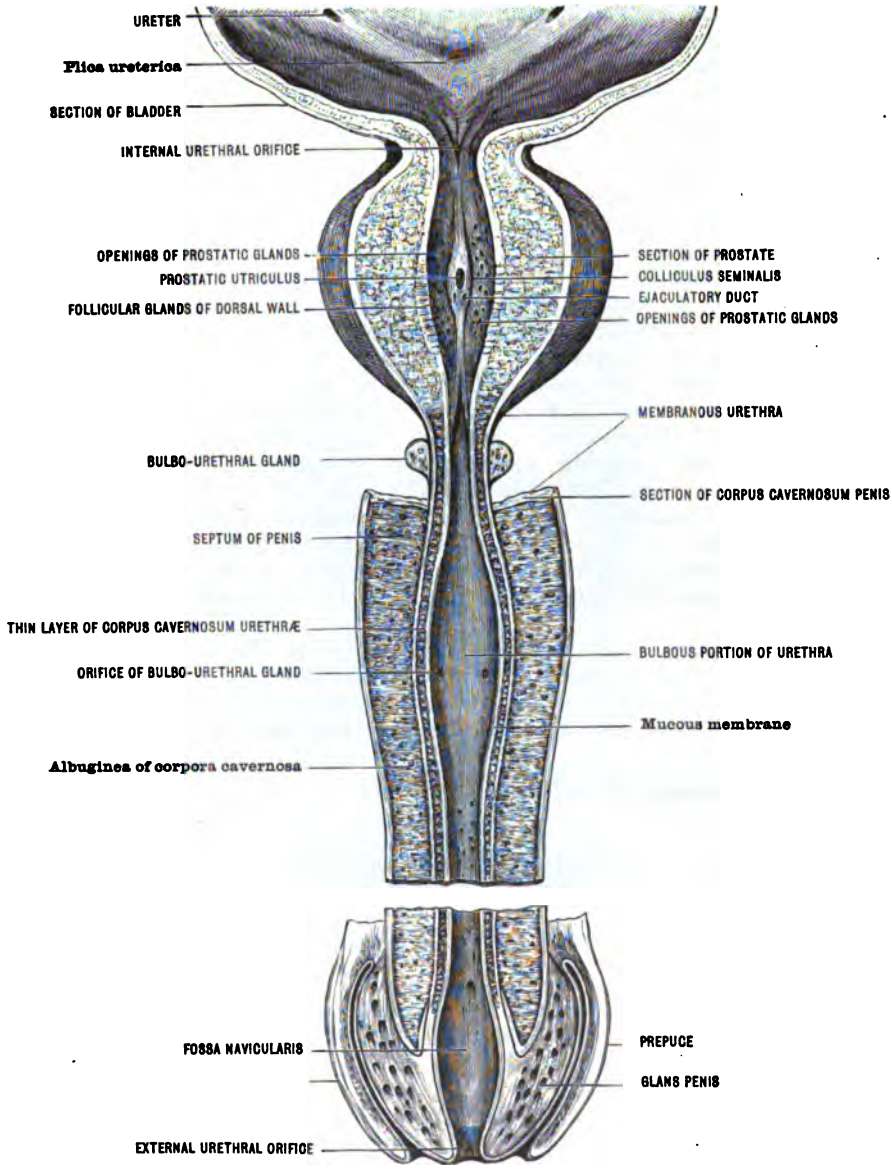
The **prostatic utriculus** is believed to be the homologue of the vagina. It is about 1·2 cm.(½ in.)in length, and terminates by a blind, slightly dilated extremity. Its walls consist of connective tissue intermingled with smooth muscular fibres, and covered with laminated epithelium. It contains a few simple or compound glands, in which small concretions are occasionally found.

The **membranous portion** is that portion of the urethra which traverses the urogenital trigone, and is about 1·2 cm. (½ in.) in length; it is inclined downwards and somewhat forwards, and lies about 2·5 cm. (1 in.) behind the subpubic ligament, from which it is separated by the muscular fibres of the deep transversus perinæi and a plexus of veins. It is closely related on either side to the bulbo-urethral (Cowper's) glands.

The *mucous membrane* resembles that of the prostatic urethra in its epithelium and erectile layer and muscularis, but surrounding these structures is a strong annular band of unstriped muscle continuous with the fibres of the prostate and forming a sphincter of considerable power. This in turn is supported by the striated fibres of the sphincter urethræ membranaceæ. The glands of the mucous membrane, simple and racemose, are similar to those of the anterior wall of the prostatic canal.

The **cavernous** or **spongy portion** extending to the extremity of the penis pre-

FIG. 872.—THE MALE URETHRA, CLEFT DORSALLY TO SHOW VENTRAL MUCOUS WALL.



sents two dilatations with an intermediate portion of narrow but uniform dimensions. The posterior expansion (**pars bulbosa**) lies in the bulb, and is about 2·5 cm. (1 in.) in length; the anterior (**fossa navicularis**) is of nearly the same extent, and is situated within the glans. The **penile angle,** formed where the flaccid organ falls from the point of suspension at the pubic region, lies about 5 cm. (2 in.) in front of the urogenital trigone; and the portion of the canal behind this is almost horizontal in direction, but with a slight upward concavity (fig. 871).

The *mucous membrane* of the cavernous urethra contains a large quantity of elastic tissue and is lined by a laminated epithelium, the superficial cells of which are prismatic in form, while the deeper layers cover in rows of more or less longitudinally disposed papillæ. At its distal extremity the integumental covering of the glans is inflected for about 6 mm. (¼ in.), the line of demarcation between the cutaneous and mucous structures being well defined. The **external orifice** is represented by a vertical slit about 7 or 8 mm. (¼ in.) in length, and is the least dilatable part of the canal; hence in urethral operations it is sometimes necessary to enlarge it by incision.

An examination of the mucous surface will show a number of orifices arranged in three longitudinal rows extending along the dorsal wall, and leading to short tubular depressions which run in a backward direction (towards the bladder) and are called the **lacunæ of Morgagni.** One of these, termed the *lacuna magna* or *sinus of Guérin*, situated in the mesial line about an inch from the external orifice, is of large size, and may arrest the point of an instrument during catheterisation. It is bounded by a little fold of mucous membrane, the valvule of Guérin, and may attain a depth of 8 mm. (⅓ in.). In addition to these are many simple and compound mucous glands (*glands of Littré*), which also occur in the prostatic and membranous portions of the canal; and the ducts of the bulbo-urethral (Cowper's) glands open into the anterior portion of the bulb on the ventral wall.

The muscular coat consists chiefly of longitudinal fibres continuous with those of the bladder, but a circular layer prolonged from the sphincteric fibres of the membranous urethra extends as an outer layer over the bulbous portion of the canal, gradually disappearing beyond this point.

As already mentioned, the collapsed urethra is represented by a fissure. This in the glans penis is vertical in direction. A short horizontal branch is superadded at the upper end of the fossa navicularis, giving the fissure the aspect of an inverted T. Above this point the horizontal limb progressively elongates, while the vertical limb shortens until the former alone is left, and the rest of the spongy urethra is represented by a transverse fissure. In the membranous segment the fissure is usually stellate, while in the prostatic region the presence of the colliculus gives it the U-like form already described. This progressive change of shape involves a kind of rifling of the tube, and probably accounts for the spiral form of the normal stream of urine.

The muscular tissue of the urethra appears to be capable of a peculiar vermicular contraction by which a catheter left within the urethra is gradually expelled, and an example is known in which an elastic instrument insecurely tied *in situ* found its way, in the reverse direction, into the bladder, and formed the nucleus of a calculus.

The **female urethra** is described on page 1193.

THE FEMALE REPRODUCTIVE ORGANS

The **female genitals** may be divided into (I) an external set of organs, which together constitute the pudendum or vulva, and (II) a set of internal organs, situated within the pelvic cavity. These latter organs are:—(1) A dilatable passage, the vagina, which communicates with the vulva; a muscular sac, the uterus, in which the ovum undergoes development, and a pair of uterine or Fallopian tubes, which serve to convey the ovum to the uterus; and (2) a pair of ovaries in which the ova are produced and which are the essential organs of reproduction.

THE VULVA

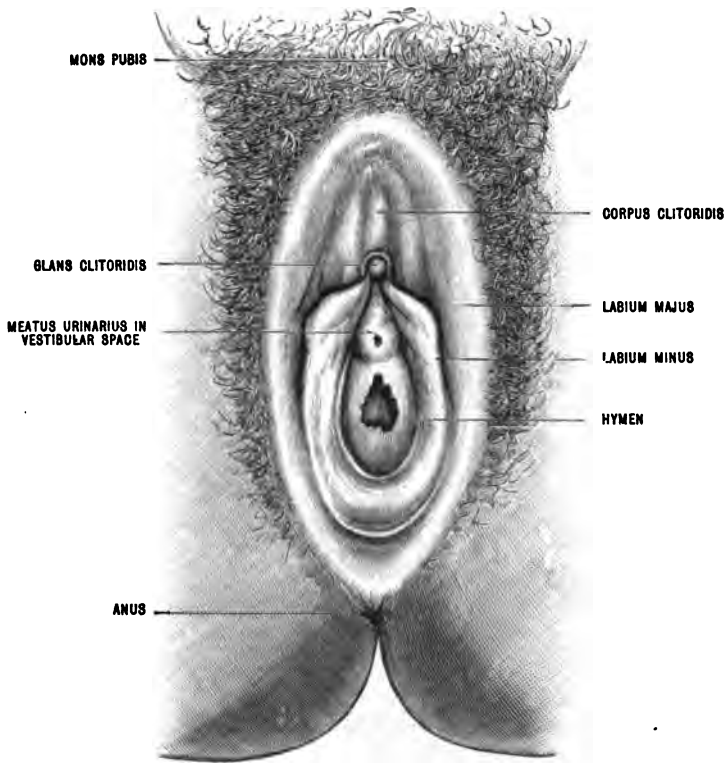
The **vulva** consists of a pair of integumentary folds, the **labia majora;** two smaller folds, the **labia minora;** a small erectile organ, the **clitoris;** and a short passage, the **vestibule,** which receives the vaginal and external urethral orifices. The vestibule is flanked on either side by an erectile body, the bulbus vestibuli, and is pierced in the middle line by the urethra (figs. 873, 874).

The **labia majora** correspond morphologically to the scrotum in the male. They are two folds of integument about 7 cm. (3 in.) in length, continuous above the symphysis with an eminence called the **mons pubis (Veneris),** and meeting below in a **posterior commissure,** or **fourchette,** about 2·5 cm. (1 in.) in front of the anus. Each labium has two surfaces: an outer, pigmented and covered with strong crisp hairs; an inner, in contact with its fellow, smooth, presenting only rudimentary hairs, but beset with large sebaceous follicles. The fissure between the two labia, called the **rima pudendi,** is horizontally placed in the erect posture.

The structures forming the labia resemble those of the scrotum, but the dartos is imperfectly developed, and each labium contains a well-defined encapsulated subcutaneous mass of fat, of somewhat ovoid shape, which blends above with the distal extremity of the round ligament. A similar mass is occasionally found in the male scrotum as a fatty tumour of the cord, and may simulate an inguinal hernia.

The **labia minora,** or **nymphæ,** are folds differing from the labia majora in their relatively small size and in the absence of hairs and fat. The two plications

FIG. 873.—THE EXTERNAL GENITALS OF THE FEMALE.



unite above, embracing the clitoris and forming the **præputium clitoridis;** below, they diverge, and terminate opposite to or a little behind the middle of the rima pudendi. They are smooth and hairless on the surface, usually of a pale rose colour, and their free border, which projects for a very variable distance, is convex and often crenulated or lobed. They are usually concealed by the labia majora, except in the fœtus; but are sometimes largely developed, and may project beyond the genital fissure, then assuming a dry pigmented aspect. The sebaceous glands are large and occupy both surfaces. They are poorly developed until puberty, and attain their greatest size during pregnancy.

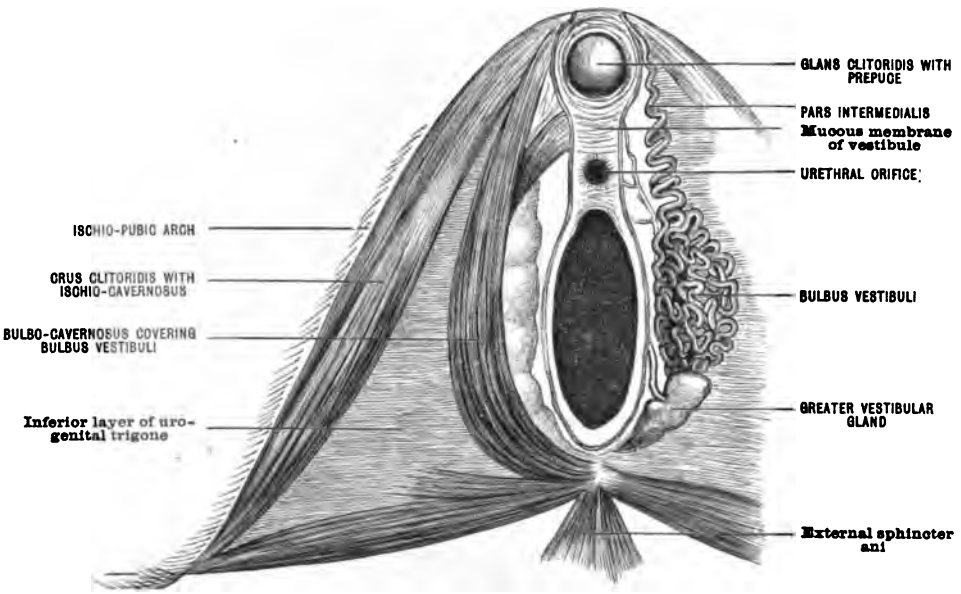
The **vestibule** is the space between the labia minora. Its boundaries are ill-defined posteriorly, and the term is used with different significance by different anatomists. Opening into it are the urethra, the greater vestibular glands, the vagina, and a few glands, the lesser vestibular, of the same nature as those of the urethra, surrounding the external orifice.

The **greater vestibular glands,** also known as the **glands of Bartholin,** represent the bulbo-urethral glands of the male, but are more superficially placed. They are two small, compound tubular glands, about 8 cm. ($\frac{1}{3}$ in.) long, situated one on either side beneath the lateral wall of the vestibule and behind the bulbi vestibuli. The single duct of each gland, about 1·8 cm. ($\frac{3}{4}$ in.) in length, opens on the floor of the vestibule, in the angle between the orifice of the vagina and the labium minus, somewhat behind the mid-transverse line of the vaginal orifice.

Vessels.—The vulvar structures are supplied by branches of the external and internal pudic arteries. The veins end in the corresponding trunks, and there is in addition a free anastomosis with the veins of the round ligament in the subcutaneous fat of the labium. The lymphatics terminate for the most part in the inguinal nodes, a few passing to the femoral nodes. About the vaginal orifice is a neutral territory in which the vulvar and vaginal absorbents intercommunicate.

The erectile structures of the vulva correspond morphologically to those of the male organ; the corpora cavernosa penis are represented by the crura and body of the clitoris, and the corpus spongiosum, cleft in the female by the vulvar orifice, appears beneath the mucous membrane of the vestibule in the form of two vascular plexuses, one on each side, called the bulbi vestibuli, and a forward prolongation

FIG. 874.—DIAGRAMMATIC REPRESENTATION OF THE PERINÆAL STRUCTURES IN THE FEMALE.



from each bulbus to the clitoris forms its glans and represents the anterior part of the corpus spongiosum.

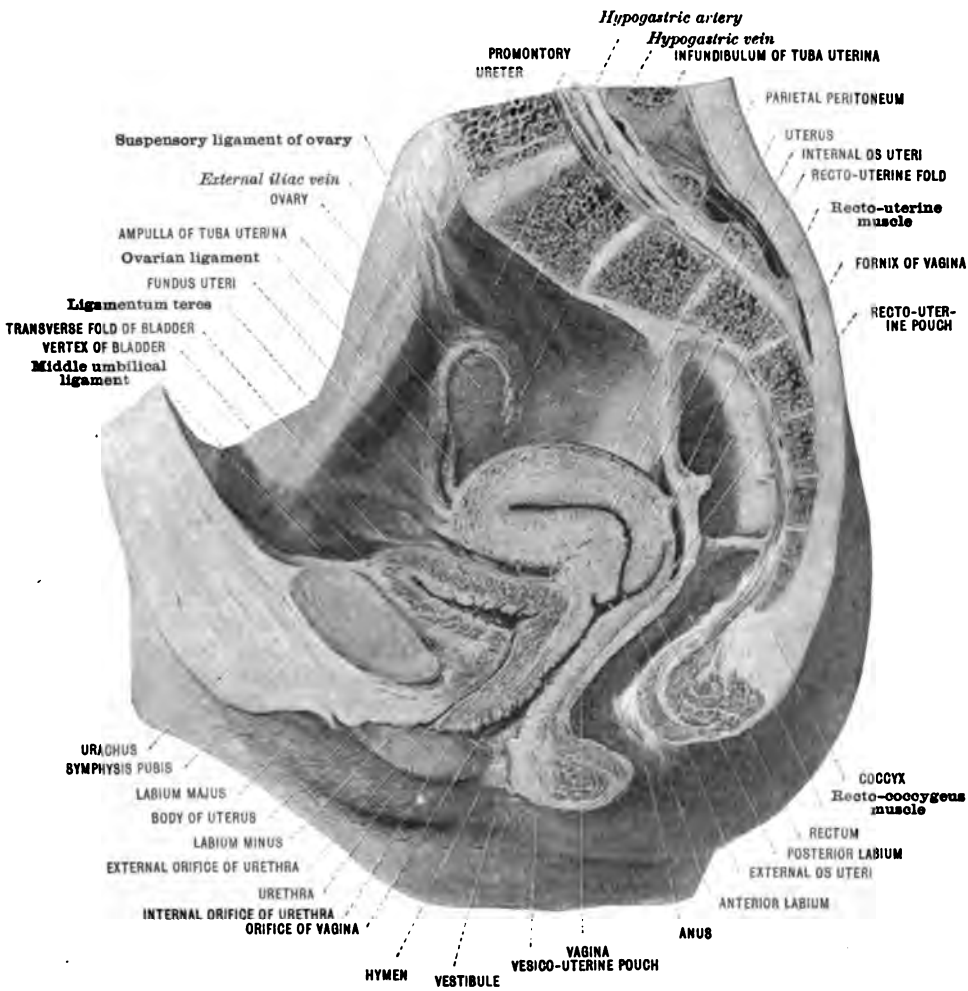
The **clitoris** is a diminutive erectile structure situated at the upper part of the vulva, and is embraced by a kind of prepuce formed by the union over it of the two labia minora. It is composed of two **corpora cavernosa** which differ from the corresponding masculine structures only in their size. They are attached posteriorly to the rami of the pubes and ischia, forming the **crura clitoridis,** and as they pass forwards, converge and meet to form the **body** of the organ. The free extremity of the clitoris is formed by a small mass of cavernous tissue, which fits like a cap over the extremities of the corpora cavernosa; it is formed by an anterior prolongation of the bulbi vestibuli and forms the **glans clitoridis,** comparable to the glans penis, but differing from it in not being perforated by the urethra.

A suspensory ligament passes from the front of the symphysis to the fascia investing the corpora cavernosa, and the entire organ is covered by integument, which is thin and adherent to the subjacent tissue in the glans, but elsewhere is freely movable.

The clitoris is relatively smaller in the adult than in the child, and is almost always concealed within the rima pudendi. It is a highly sensitive organ, and is capable of erection.

The **bulbi vestibuli** are two erectile bodies of somewhat pyriform shape, lying one on either side of the vestibule beneath the mucous membrane. The larger extremity of each is posterior and extends backwards nearly to the posterior commissure, touching the greater vestibular gland. The narrow anterior extremity, the **pars intermedia** of Köbelt, runs forwards to meet its fellow of the opposite side beneath the clitoris, and forms the terminal part of that organ, the glans clitoridis. Superiorly, it is fixed to the superficial layer of the urogenital trigone of the perinæum, while it is in relation internally to the urethral and vaginal orifices, and externally is invested by the fibres of the bulbo-cavernosus. It consists of greatly contorted, anastomosing blood-vessels, which form an erectile tissue enveloped by a

FIG. 875.—SECTION OF THE FEMALE PELVIS. (Spalteholz.)



thin tunica albuginea. During the condition of engorgement it helps to narrow the vestibular portion of the vulva and the entrance of the vagina.

The **vessels** and **nerves** of the clitoris and bulbi vestibuli are the same as those of the analogous parts of the male.

The **muscles** appended to the erectile structures are very similar to those occurring in connection with the penis; they are the ischio-cavernosi, the bulbo-cavernosi, and the transversi perinæi, and will be described in connection with the perinæum.

The urethra (figs. 875, 876).—The female urethra represents only the upper part of the male canal, and is similarly related to the urogenital trigone. It is about 4 cm. (1½ in.) in length, and is directed upwards and slightly backwards to open into the bladder about 2·5 cm. (1 in.) behind the middle of the symphysis. Its

posterior wall is in contact with the vagina, and it is surrounded in front and at the sides by the pudendal plexus of veins. The posterior margin of the external orifice usually presents a tubercular prominence by which the position of the orifice may be distinguished during catheterisation.

As in the male urethra, the narrowest portion of the canal is the external orifice, but the whole tube is sufficiently dilatable in most cases to allow the careful introduction of the finger while the patient is under an anæsthetic. A case is recorded by William Cowper (1697) in which, as a result of an imperforate condition of the hymen, it became the channel of sexual congress.

Structurally it consists of a highly elastic mucous membrane and a strong muscular coat. The **mucosa** is lined with three or four layers of epithelial cells, the more superficial of which are prismatic in form, and presents numerous lacunæ and glandular follicles, corresponding to the glands of Littré of the male. In addition, two slender elongated ducts, the **praurethral ducts,** also known as the **ducts of Skene,** open either upon the ventral wall of the urethra, near its external orifice, or else directly into the vestibule immediately below the urethra. They vary greatly in length (0·5–2·0 cm. or even 4·0 cm.), and are regarded by some anatomists (Waldeyer) as representatives of the prostatic glands. The muscular coat of the urethra is divisible into external circular and internal longitudinal layers, both intermingled with fibres of elastic tissue and with large venous plexuses which may undergo varicose dilatation near the external orifice and form a pile-like tumour. The circular fibres are very strongly developed at the vesical end of the canal and constitute a powerful sphincter; these are surrounded by a quantity of striped and unstriped fibres which form an incomplete ring, deficient only in its posterior or vaginal segment, and probably represent the prostatic fibres of the male. The external orifice is surrounded by a muscular sphincter composed of striped fibres derived from the bulbo-cavernosus.

THE VAGINA

The **vagina** is a passage which extends upwards and slightly backwards from its external opening at the vestibule, and terminates above by embracing the neck of the uterus. Its vulvar aperture is guarded in the virgin by a fold of mucous membrane called the **hymen.**

Form and direction (figs. 875, 876).—In its ordinary condition the vaginal canal is represented by a fissure which in horizontal section resembles the form of the letter H, with a transverse limb about an inch in length and two short vertical limbs (fig. 876). In longitudinal section (fig. 875) the fissure branches above, a short limb (occasionally ill-marked or absent) passing in front of the anterior lip of the external os uteri, and a much longer limb extending behind the os to end about 2 cm. ($\frac{3}{4}$ in.) above the extremity of the posterior lip. In consequence of this arrangement the lower portion of the neck of the uterus seems to project obliquely into the cavity of the vagina, and the protruding portion is covered by mucous membrane continuous with that of the vagina, the line of reflection of the membrane from the vaginal to the uterine walls being termed the **fornix.** The direction of the passage is upwards and backwards, forming an angle of about 30° with the long axis of the body, and usually presenting a slight posterior concavity adapted to the convexity of the rectal ampulla; the course and direction, however, vary with the degree of pelvic inclination peculiar to the individual, and to some extent with the condition of the bladder and rectum.

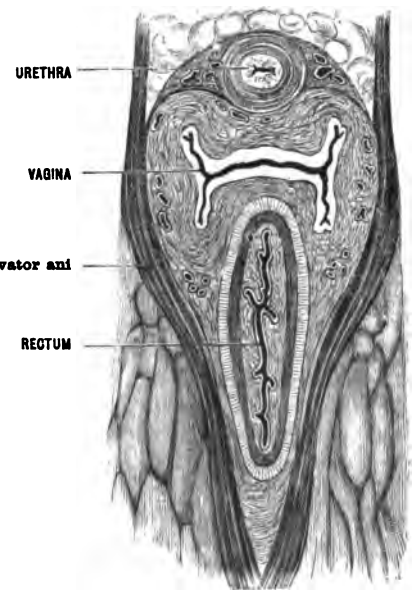
Owing to the obliquity of the vagina to both the axis of the body and to the uterus, its two walls are of very unequal length, the anterior measuring from 7 to 8 cm. ($2\frac{3}{4}$ to $3\frac{1}{2}$ in.), while the posterior is prolonged upwards nearly 2 cm. further, measuring from 8 to 10 cm. ($3\frac{1}{2}$ to 4 in.). The canal as a whole is narrowest below, and gradually increases as it ascends, reaching its greatest admeasurement where it surrounds the os uteri. Its dilatability is enormous, as may be inferred from the passage of the fœtus in parturition.

Relations.—Anteriorly, it is opposed to the urethra and posterior wall of the bladder. It is intimately united with the lower two-thirds of the urethra, but is separated from the upper third and from the bladder by loose connective tissue continuous with the subperitoneal fascia. The ureters pierce the vesical wall in front of the vagina, 3 cm. ($1\frac{1}{4}$ in.) below the level of the os uteri. **Posteriorly,** the

vagina is in relation with the rectum, but is separated from it above for about 1·8 cm. ($\frac{3}{4}$ in.) by the peritoneal *cul-de-sac* called the **recto-uterine pouch (pouch of Douglas),** in the middle by subperitoneal connective tissue, and below by the tissues of the perinæal body. In the latter situation the two canals diverge, and the perinæal body hence appears on sagittal section as a triangle, the base of which is formed by the integument. **Laterally,** it is in contact with the vaginal branch of the uterine artery, and a venous plexus lying in the subperitoneal tissue at the base of the broad ligaments. It is crossed obliquely in its upper third by the ureters, and in its lower two-thirds by the anterior borders of the levatores ani. The finger passed within the passage and pressed to either side may be made to feel the resistance of the pelvic wall, and to distinguish the presence or absence of morbid growths or effusions. The **duct of Gärtner,** a relic of the Wolffian duct, may occasionally be found by the side of the upper half of the vagina as a minute tube or fibrous cord.

The lower end of the vagina pierces the urogenital trigone, and it is here that the resistance to dilatation is greatest. The inlet may be temporarily narrowed by the engorgement of the bulbi vestibuli, or by the action of the bulbo-cavernosi and perhaps also by that of the levatores ani.

FIG. 876.—HORIZONTAL SECTION OF VAGINA AND ADJACENT STRUCTURES. (After Henle.)



The **mucous surface** of the anterior wall of the vagina presents in the median line a well-marked longitudinal elevation, the **anterior columna rugarum,** which, in its lower half, where it lies immediately behind the urethra, is especially distinct and is termed the **urethral carina.** Upon the posterior wall a **posterior columna rugarum** occurs, and from both columnæ transverse **rugæ** pass laterally on either side. These markings diminish in distinctness with advance in age and with successive parturitions. The mucous membrane is of a pale rose colour in periods of quiescence, but becomes turgid during the catamenial period and in pregnancy.

The **hymen** has been a subject of much speculation amongst the learned and unlearned of all ages. Its very existence was at one time denied by many great authorities, and the significance to be attached to its presence or absence may still be a question in medical jurisprudence. It is a fold of connective tissue, rich in blood-vessels and lined on both surfaces by mucous membrane, which, in the virgin, partially closes the vaginal orifice. It usually has a somewhat semilunar form, surrounding the more posterior portions of the orifice, but it may be represented by a circular curtain pierced by one, two, or more apertures. It varies greatly in strength and elasticity, and although it is nearly always ruptured by the first act of

sexual congress, it may remain unbroken until parturition. An imperforate condition of the membrane is occasionally present, and may necessitate a surgical operation at the commencement of the menstrual period. After rupture the remains of the hymen persist as small lobed or wart-like structures, the **carunculæ hymenales (myrtiformes)**, around the vaginal orifice.

Structure.—The vaginal wall is composed of three coats, fibrous, muscular, and mucous, and has a thickness of 3 to 4 cm. The outer **fibrous** coat is derived from the endopelvic fascia, and holds in its meshes a plexus of veins. The **muscular** coat is strong, and is composed of unstriped fibres continuous above with the uterine musculature. The fibres are mainly longitudinal in direction, but circular fibres are said to occur upon the inner surface of the coat. The striped fibres of the bulbocavernosus surround the external orifice, forming what may be regarded as a sphincter (**sphincter vaginæ**).

The **mucous membrane** is highly elastic, beset with papillæ and covered with a squamous laminated epithelium continuous with that of the os uteri and vulva. It has no glands, the fluid which moistens it being probably produced by the cervical and uterine glands.

Vessels and nerves.—The **arteries** of the upper part of the vagina are derived from the vaginal branch of the uterine; in its middle part it is supplied from the inferior vesical; and in its lower part from the middle hæmorrhoidal and internal pudic. Not infrequently these various branches anastomose on the posterior surface of the vagina to form a median unpaired stem, the *azygos artery* of the vagina. The **veins** form a rich network in the muscular and mucous coats, and terminate in a plexus drained by the hypogastric (internal iliac) vein. The **lymphatics,** arranged in two intercommunicating networks, mucous and muscular, form numerous trunks which accompany the veins and terminate in the hypogastric and iliac nodes, a few from the neighbourhood of the vestibule, however, reaching the inguinal nodes, and branches from the posterior surface pass to the ano-rectal nodes.

The **Nerves** come from the hypogastric plexus, the fourth sacral, and the pudic.

THE UTERUS

The **uterus, or womb** (figs. 877, 878), is a hollow muscular organ lined with mucous membrane. It communicates above with the two Fallopian tubes, and below with the vagina, and lies within the pelvic cavity between the bladder and rectum, fixed in its place by folds of peritoneum and certain bands of unstriped muscle. It varies greatly in size and form at different periods of life and under different physiological conditions.

The adult uterus is flattened from before backwards, pyriform in its outlines when seen from the front, and is divided into two main portions, body and cervix, by a transverse constriction, the isthmus. The **isthmus** may be regarded as the weak point in the organ, and it is here that the various pathological flexions take place. Its position in the virgin uterus is about midway between the two extremities, but it lies near the junction of the middle and lower thirds in women who have borne children.

The upper portion, or **body,** presents two surfaces, three borders, and two angles. The **vesical** or **anterior surface** is almost flat, and is covered by a layer of peritoneum which is reflected at the level of the isthmus upon the bladder, forming a shallow utero-vesical pouch. The **intestinal** or **posterior surface** is distinctly convex, and covered in its whole extent by a layer of peritoneum which is prolonged downwards over the neck and for a short distance upon the posterior wall of the vagina before undergoing reflexion upon the rectum to form the **recto-uterine pouch,** or **pouch of Douglas.** The **superior border** is thick and rounded, and is covered by peritoneum, which passes from the anterior to the posterior surface. The **lateral borders,** slightly convex and running downwards and inwards, correspond to the line of attachment of the peritoneal folds called the **broad ligaments.** The **superior angles,** at the junction of the superior with the lateral borders, give attachment to the oviducts or Fallopian tubes. The term **fundus** is loosely applied to the upper part of the body.

The **cervix** is cylindrical in section, wider in the middle than above or below,

and may be divided into three portions,—an upper **supravaginal zone,** a middle **zone of vaginal attachment,** and a lower **intravaginal zone,** the **os uteri.** The **supravaginal zone,** representing about one-half of the neck behind and two-thirds in front, is in relation anteriorly with the bladder; posteriorly it is covered with the peritoneum of the anterior wall of the pouch of Douglas, and at the sides it is connected with the broad ligaments, in which lie the uterine vessels and the ureter,

FIG. 877.—THE FEMALE ORGANS OF GENERATION. (Modified from Sappey.)
(Vagina divided and laid open behind.)

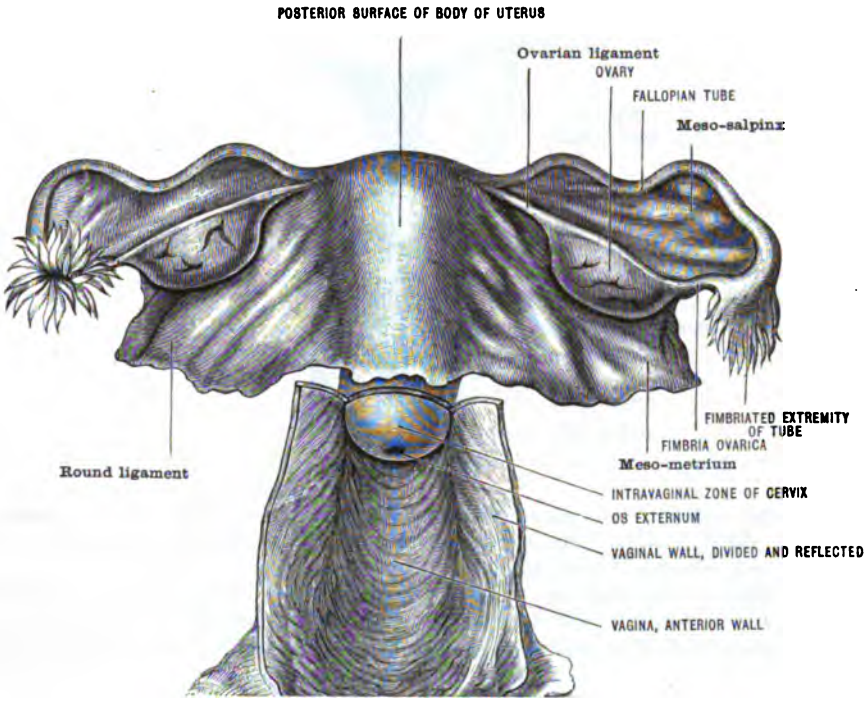
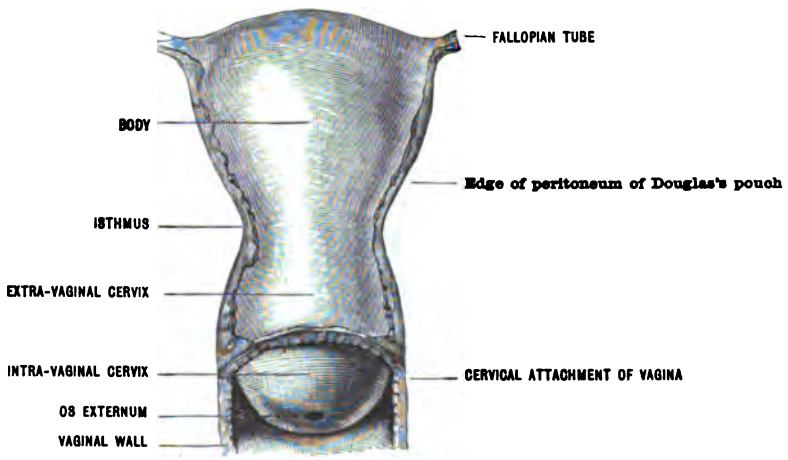


FIG. 878.—THE POSTERIOR SURFACE OF THE UTERUS. (After Sappey.)

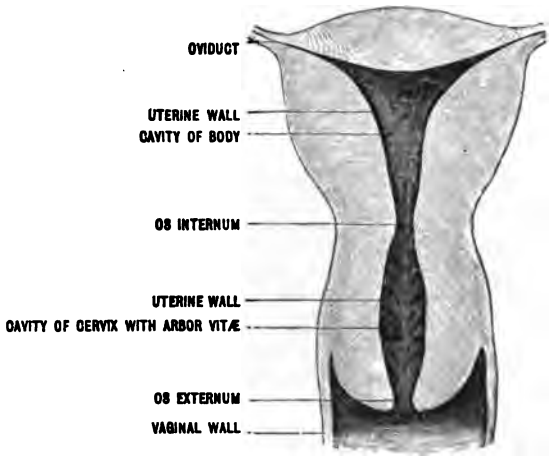


the latter at a distance of about 2 cm. (¾ in.). The **zone of vaginal attachment** is obliquely set, extending higher behind than in front, and has a depth of about 5 mm. (¼ in.). The **intravaginal zone** is covered with mucous membrane continuous with that of the vagina. It presents the external aperture (**os externum**) of the uterine cavity, usually in the form of a transverse fissure, about 6 mm. (¼ in.)

in length, bounded by two prominent **labia,** anterior and posterior, both of which are in contact with the posterior wall of the vagina. The anterior lip is the thicker, the shorter, and the lower; the posterior lip is longer on account of the greater height of the posterior vaginal fornix. After childbirth the labia usually become notched and irregular.

Dimensions.—The size of the uterus varies within wide limits. Its average length in the nulliparous adult is about 6·5 cm. (2½ in.) and its greatest breadth

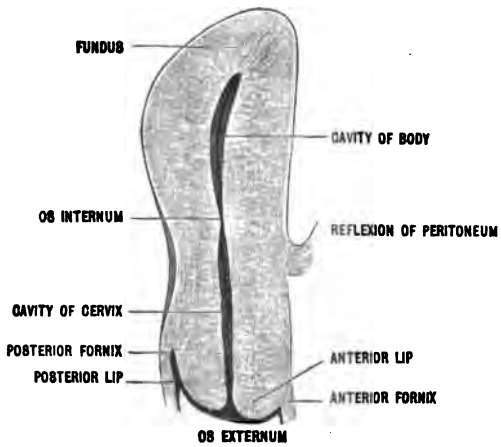
FIG. 879.—FRONTAL SECTION OF THE VIRGIN UTERUS. (After Sappey.)



about 4 cm. (1½ in.), but in women who have borne children these dimensions are about one-fifth greater. Its weight averages between 40 and 50 gm. in nulliparæ, and between 60 and 70 gm. in multiparæ.

Direction.—The direction of the uterine axis is undoubtedly variable within considerable limits, not only in different individuals, but also in any one individual in connection with the degree of distension of the bladder and rectum. In what

FIG. 880.—SAGITTAL SECTION OF THE VIRGIN UTERUS. (After Sappey.)



may be regarded as the typical condition (fig. 875), the external os uteri lies about at the level of the upper border of the symphysis pubis and in the plane of the spines of the ischia. From this point the axis of the cervix uteri is directed upwards and slightly forwards, so that the entire uterus is anteverted, and, furthermore, the body of the organ is bent forward (anteflexed) upon the cervix at the isthmus, so that the axes of the two portions make an angle, open anteriorly, of from 70° to

100°. (Waldeyer.) Frequently also the organ is slightly inclined either to the right or to the left.

Variations in form according to age.—In young children the body is but slightly developed in proportion to the cervix, and the prominence of the intravaginal segment is relatively great. In the virgin uterus of a young adult the length is about equally divided between body and cervix, but after childbirth the body never returns to its original size, and its length when involution is complete is nearly double that of the neck. In old age the entire organ undergoes atrophy.

The **cavity** of the uterus is reduced to a fissure by the antero-posterior flattening of the walls. It is divisible into two segments, that of the body and that of the neck. The shape of the **cavity of the body** is that of a triangle with convex sides (in the virgin) and three open angles. At the two superior angles are the orifices of the oviducts, and the lower angle presents the os uteri internum or aperture of communication with the neck. The walls are smooth, and moistened with mucus.

The **cavity of the neck** is fusiform, terminating in the **os internum** above and in the **os externum** below. The superior opening is circular, the inferior usually in the form of a transverse fissure. The mucous lining of the anterior and posterior walls presents ridges which bear some resemblance to those of the vagina, but are dependent upon the arrangement of the innermost layers of the muscular wall, and not upon a simple plication of the mucous membrane. The whole length of each wall is traversed by a longitudinal nearly median ridge or stem, from which pass a number of branches in an outward and slightly upward direction. The figure formed by these folds (**plicæ palmatæ**) is designated by the name of *arbor vitæ uterina;* it is most marked in the young, and tends to effacement after repeated parturitions. The cavity usually contains a plug of alkaline mucus.

The average length of the entire cavity in the nulliparous adult is about 5·5 cm. (2⅛ in.); in multiparæ, 6·5 cm. (2⅝ in.). The greatest transverse diameter is a little less than half of these measurements.

Structure.—The uterus is composed of three coats—an outer serous, a middle muscular, and an inner mucous. The **serous membrane,** also termed the **perimetrium,** is the portion of the peritoneum which is in relation with the uterus, and covers the upper half or two-thirds of its anterior surface, the whole of the supravaginal portion of the posterior surface, and the summit. At the sides it is continuous with the layers of the broad ligament. Over the fundus and greater portion of the body of the uterus the perimetrium is thin and firmly adherent to the subjacent muscular coat, so that it cannot be readily separated. But over the posterior surface of the cervix it is thicker, and is separated from the muscular coat by a layer of loose connective tissue, the **parametrium,** which also intervenes between the anterior surface of the cervix and the bladder, and extends upwards along the sides of the uterus between the two layers of the broad ligament. Owing to this disposition of the subserous tissue, the whole of the cervix uteri may be amputated without encroaching upon the peritoneal cavity.

The **muscular coat** or **myometrium** constitutes the greater part of the thickness of the organ. The arrangement of the fibres is very complex, but a fairly satisfactory division into three layers may be demonstrated:—a thin **outer** layer, partly longitudinal, partly transverse in direction, continuous with the muscular fibres of the Fallopian tubes, vagina, round, ovarian, and utero-sacral ligaments, and with the muscular expansion in the broad ligaments; a **middle layer,** very thick, its fibres plexiform, running in all directions, and intermingled with large venous plexuses in the body of the uterus, the innermost strands forming sphincteric rings around the os internum and around the orifices of the oviducts; and a thin **internal layer,** longitudinal in the body, and producing the ridges of the arbor vitæ in the cervix.

The **mucous membrane** or **endometrium** of the *body* is smooth and pale, lined with cylindrical ciliated epithelium, and pierced by innumerable tubular glands. The ciliary motion is from above downwards. The mucous membrane of the cavity of the *neck* is thicker and is plicated in the manner already described; its epithelium is ciliated down to the external opening, but there undergoes a transition into the squamous laminated epithelium which covers the intravaginal portion of the os. Many tubular and racemose mucous glands open into the furrows of the arbor vitæ, and these are liable to pathological changes which cause them to assume

a vesicular character, when they are sometimes known under the fanciful name of **ovula Nabothi.**

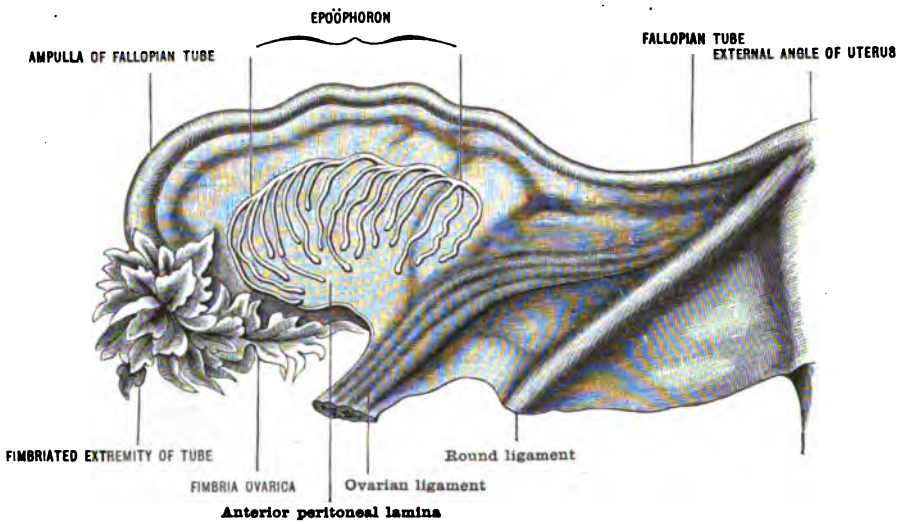
There is no distinct submucous layer, the endometrium resting directly on the muscular coat.

Ligaments.—The so-called ligaments of the uterus are of two kinds, peritoneal and fibro-muscular.

The **peritoneal ligaments** are four in number: two lateral, and two posterior.

The **broad** or **lateral ligaments** (fig. 881), called also **alæ vespertilionis** from their fancied resemblance to the wings of a bat, are formed by two layers of peritoneum extending from the sides of the uterus, where they are continuous with the perimetrium, transversely outwards to the sides of the pelvis. The two layers of peritoneum are continuous above and form the free border of the ligament, but diverge laterally and below, where they become continuous with the parietal peritoneum. Each ligament presents two surfaces and four borders. The **tubal** or **superior border** is the free border formed by the fusion of the two layers of the ligament over the Fallopian tube; it terminates laterally at the infundibulum of the tube. The **lateral border** forms a thin free edge, extending from the infundibulum to the lateral wall of the pelvis, where the ovarian vessels pass between two layers of the ligament. On account of its connections, this border is also termed the **infundibulo-**

FIG. 881.—THE BROAD LIGAMENT AND ITS CONTENTS, SEEN FROM THE FRONT. (After Sappey.)



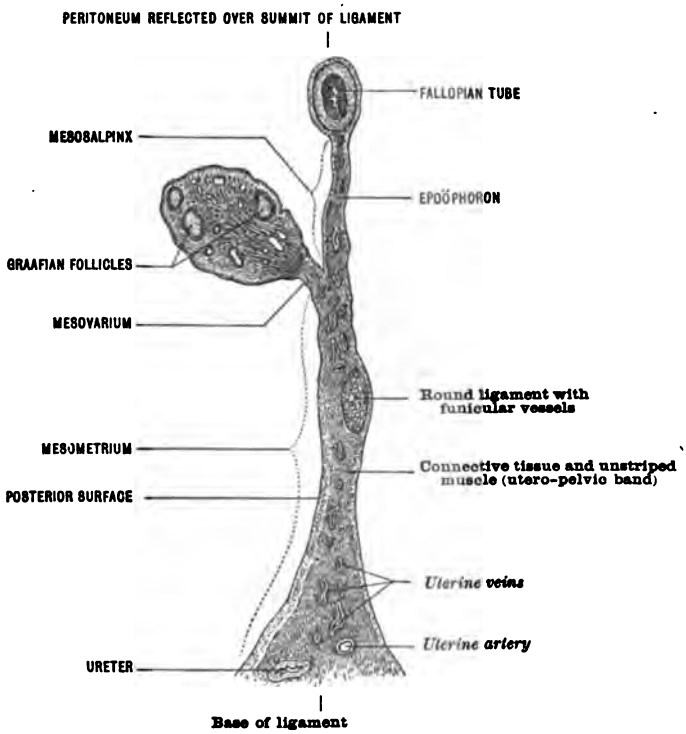
pelvic ligament. The **inferior border** is attached to the floor and sides of the pelvis, resting upon the endopelvic fascia and the levator ani muscle, and, more laterally, upon the internal obturator muscle. Along it the uterine vessels and the ureter pass forwards and inwards towards the uterus, and it contains the largest part of the parametrium. The **uterine** or **internal border** is attached to the lateral border of the supravaginal portion of the cervix and of the body of the uterus; the uterine vessels ascend along it in the parametrium.

The anterior layer of the broad ligament is reflected upon the pelvic floor at a somewhat higher level than the posterior one, and the **anterior surface** of the ligament is, consequently, somewhat the narrower of the two. The posterior surface has projecting posteriorly from its upper part the ovary, which is attached to the ligament by a double layer of peritoneum termed the **mesovarium.** Medially this fold is continued to the body of the uterus over the ovarian ligament, and laterally it extends towards the ovarian fimbria of the infundibulum. It divides the broad ligament into an upper and a lower portion, the former, extending between the line of attachment of the mesovarium and the Fallopian tube, being known as the **meso-salpinx,** while the lower portion is termed the **meso-metrium.**

The **structures enclosed between the two layers of the broad ligament** are:—

(1) The **ovarian ligament,** composed of unstriped muscular fibre, passing between the side of the uterus and the inner or lower extremity of the ovary. (2) The **Fallopian tube,** lying at the upper margin immediately beneath the line of continuity of the two laminæ; its outer fimbriated extremity turned backwards and inwards to the ovary, and attached by one of the fringes to the outer or lower end of the organ. It does not reach quite to the pelvic wall. (3) The **round ligament,** a muscular band running downwards and outwards, forming a ridge beneath the anterior lamina, and eventually passing to the internal inguinal ring and through the inguinal canal into the labium. (4) Fœtal relics: (*a*) the **epoöphoron,** or **parovarium,** a group of twelve to twenty effete tubules of the Wolffian body lying close to the attached border of the ovary, corresponding to the vasa efferentia of the testicle, and joining above a kind of collecting tube which is the persistent upper portion of the Wolffian duct. (*b*) The **paroöphoron,** a few scattered, imperfectly developed tubes in the neighbourhood of the epoöphoron, also representing traces of the Wolffian body. They are usually seen as small whitish or yellowish grains

FIG. 882.—DIAGRAMMATIC SECTION OF THE BROAD LIGAMENT.



in the infant, but are rarely demonstrable in the adult. (5) The uterine, ovarian, and funicular vessels, anastomosing near the angle of the uterus; and the uterine plexus of nerves. (6) A quantity of loose adipose cellular tissue lying between the muscular and other structures and the serous membrane, and in continuity with the subperitoneal fascia of the pelvis. (7) Involuntary muscular fibres passing from the obturator fascia to become attached to the sides of the uterus and vagina, ensheathing the vessels and serving as a support to the uterus. They may be compared with the fibro-muscular subperitoneal bands supporting the third stage of the duodenum, the transverse colon and small intestines, and are essentially sustentacular in relation to the viscera and to their vessels and nerves.

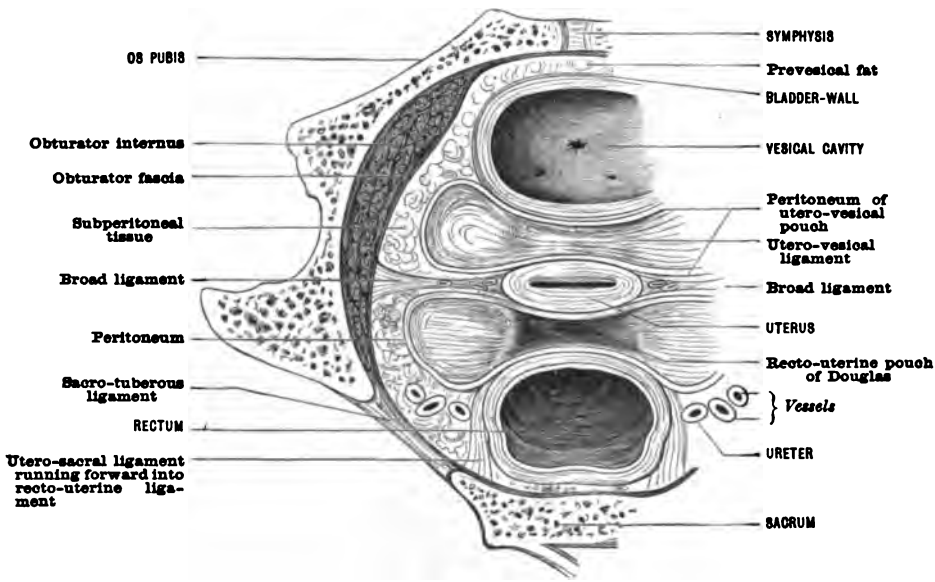
The **posterior peritoneal** or **recto-uterine ligaments** are two peritoneal folds which run backwards from the intraperitoneal portion of the cervix uteri and vagina to become continuous with the peritoneal investment of the second stage of the rectum. They form the lateral boundaries of the pouch of Douglas, and between their layers lie the **utero-sacral ligaments,** together with some loose connective

tissue and a number of anastomosing branches of the uterine and hæmorrhoidal vessels.

The **fibro-muscular ligaments** lying between the peritoneal folds are three pairs: two in the broad ligaments, the round, and the ovarian, and one in the posterior ligaments, the utero-sacral. They have already been briefly referred to.

The **ligamentum teres** or **round ligament** (fig. 884) is a cord, from 12 to 15 cm. (4⅘–to 6 in.) in length, attached to the uterus just below the Fallopian tube, and there continuous with the superficial uterine fibres. From this point it runs obliquely downwards, outwards, and forwards, immediately beneath the anterior layer of the broad ligament, to reach the pelvic wall; it then loops around the curve of the inferior epigastric artery on the inner side of the external iliac artery, and enters the inguinal canal at the abdominal ring. In its course through the canal it is supplemented by some striped fibres derived from the muscular walls of the abdomen, and it may be accompanied by a tube of peritoneum, the **vaginal process (canal of Nuck)**, which is constant in the fœtus and not infrequently persistent during childhood and even adult life. The ligament then gives off a few of its newly acquired striped fibres to the pillars of the ring and to the pubic tubercle, and emerging from the external ring, finally breaks up into a number of delicate fasciculi

FIG. 883.—SECTION OF THE PELVIS SHOWING THE LIGAMENTS OF THE UTERUS.



which become lost amongst the interlobular connective tissue of the large pad of fat which occupies the labium majus.

In structure it is composed of unstriped muscle with areolar and elastic tissue, reinforced in the inguinal canal by striated muscular fibres and funicular vessels and nerves. The **a. funiculi teretis (funicular artery)**, conveyed by the round ligament, is a branch of the inferior epigastric. It is accompanied by a plexus of veins, and anastomoses in the labium with branches of the internal pudic, and at the superior angle of the uterus with the uterine and ovarian.

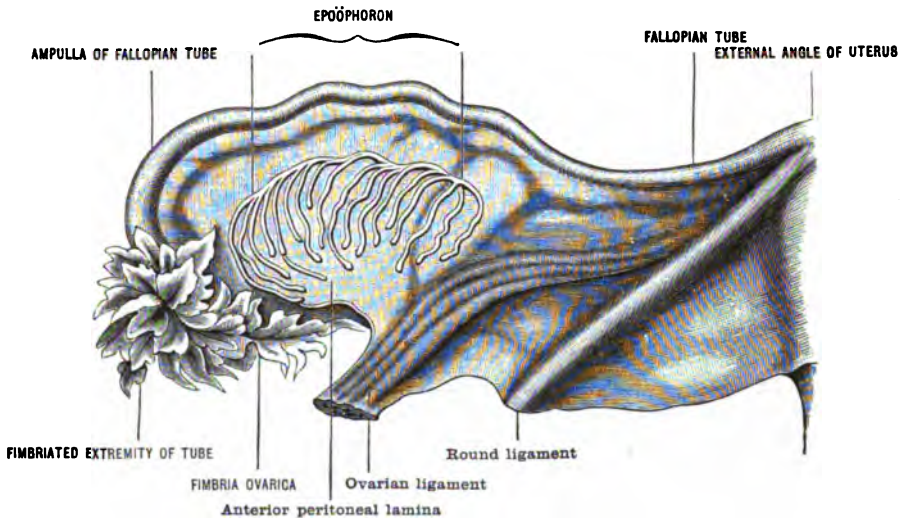
The **utero-sacral ligaments** (fig. 883) are flat fibro-muscular bands, extending from the highest part of the cervix uteri, where they are more or less continuous with the uterine fibres in the recto-uterine peritoneal folds, to the sides of the sacrum opposite the lower border of the sacro-iliac synchondroses. They run one on each side of the rectum near the junction of the first and second stages of this portion of the intestine, their muscle-fibres (the **recto-uterine muscles**) becoming continuous with those of the rectum, and more anteriorly they lie in the recto-uterine peritoneal folds, which form the lateral boundaries of the pouch of Douglas.

The **ovarian ligaments** (fig. 884) are short rounded cords continuous with the uterus at the superior angle of the organ behind the Fallopian tube, and joining

externally the inner end and attached border of each ovary. These various ligamentous structures all serve to maintain the normal position of the uterus. In addition, the ovarian ligament aids in the fixation of the ovary, and the round ligaments form protective sheaths for vessels and nerves.

Vessels and nerves.—The principal **artery** of the uterus is the uterine, whose terminal portion ascends along the lateral border of the uterus in a very tortuous course through the parametrium, giving off, as it goes, lateral branches to both surfaces of the organ. Above it anastomoses with the ovarian artery, and this vessel, together with the art. ligamenti teretis (funicular artery), a branch of the inferior epigastric, form important accessory sources of blood-supply during pregnancy. The **veins** in issuing from the uterus unite around the artery to form a

FIG. 884.—THE BROAD LIGAMENT AND ITS CONTENTS, SEEN FROM THE FRONT. (After Sappey.)



pampiniform plexus, which is drained by the uterine and ovarian veins. The **lymphatics** from the upper part of the uterus pass along into the ovarian veins and terminate in the lumbar nodes; those from the body and cervix pass to the hypogastric nodes, situated in the angle between the hypogastric (internal iliac) and external iliac vessels. Some stems accompany the vessels of the round ligament to the inguinal nodes.

The **nerves** of the uterus come in part from the third and fourth sacral nerves and in part from the hypogastric sympathetic plexus. The nerves from the latter source accompany the utero-sacral ligaments to the cervix, where they come into connection with a large ganglion, and are thence distributed to the uterine walls

THE TUBÆ UTERINÆ OR FALLOPIAN TUBES

The **tubæ uterinæ** or **Fallopian tubes** (fig. 884) may be regarded both in structure and morphology as prolongations of the uterus. They are two trumpet-shaped tubes structurally continuous with the superior angles of the uterus, and running in the superior border of the broad ligaments to become closely connected with the ovaries, partly by direct attachment, partly by a peculiar contiguity. Each duct opens internally into the uterine cavity, and its external orifice establishes a continuity between the tubal cavity and that of the peritoneum, but under normal circumstances is closely applied to the surface of the ovary, and receives the ova which are detached from that organ, transmitting them to the uterine cavity. Hence the tubes are sometimes termed oviducts. Each tube is from 10 to 15 cm. (4 to 6 in.) in length, and consists of a narrow, straight portion, the **isthmus,** from 3 to 6 cm. (1¼–2½ in.) long, immediately adjoining the uterus, followed by a broader,

flexuous portion, the **ampulla,** which terminates in a funnel-like dilatation, the **infundibulum.** The cavity of the ampulla communicates with that of the infundibulum by means of the **ostium abdominale,** and the margin of the infundibulum is fringed by numerous diverging processes or **fimbriæ,** one of which, the **fimbria ovarica,** attains a length of from 2·5 to 3 cm. (1–1¼ in.), and extends along the free border of the meso-salpinx (the infundibulo-pelvic ligament) to reach the tubal extremity of the ovary.

The diameter of the isthmus is about 3 mm. (⅛ in.), and that of the ampulla at its widest portion is about 8 mm. (⅓ in.). The ostium abdominale measures 2 or 3 mm. (1/12 in.) in diameter, and the mouth of the infundibulum, exclusive of the fimbriæ, from 6 to 8 mm. (¼–⅓ in.). The tubes are capable of great distension, as is shown by the occurrence of tubal pregnancies, and considerable variation occurs in the flexures of the ampulla. Occasionally accessory ostia, provided with fimbriæ, occur, and the fimbria ovarica has attached to it a stalked vesicle, the **hydatid of Morgagni,** similar to the body of the same name occurring in connection with the testis.

The **course** of each tube is at first almost horizontal, passing outwards and slightly backwards to the lateral pelvic wall, where it comes into relation with the uterine pole of the ovary. It then bends at right angles and passes almost vertically upwards to the tubal extremity of the ovary, and then curves downwards and backwards so that the mouth of the infundibulum and the fimbriæ rest upon the internal surface of the ovary (fig. 861).

Structure.—The tube has four coats—serous, adventitious, muscular, and mucous. The **serous coat,** formed by the layers of the broad ligament, is incomplete, like that of the small intestine, the muscular tunic being uncovered by peritoneum for about the lower one-fourth or one-fifth of its circumference, and hence a rupture of the duct may lead to an escape of its contents either into the peritoneal cavity or into the interserous space between the layers of the broad ligament. The **adventitious coat** is rich in vessels, and continuous with the subperitoneal tissue of the broad ligament. The **muscular coat** consists of circular and longitudinal fibres; the latter for the most part sparingly distributed outside the former, but near the outer extremity of the tube appearing also as an innermost layer. The circular layer is most attenuated near the fimbriated extremity. The **mucous membrane** is characterised mainly by its plications. The folds are longitudinal in direction, and relatively simple in the isthmus, where the cavity appears as a stellate fissure when cut across; but in the ampulla the foldings are very complex, and in a transverse section present a deceptive appearance of branching tubular glands within the depth of a thick mucosa. At the fimbriated extremity of the tube, the plications are continued on to the fringes. The epithelium is cylindrical and ciliated, the motion of the cilia being towards the uterus. At the trumpet-shaped extremity it passes gradually into the pavement epithelium of the serous membrane. There is no sub-mucous layer.

Vessels and nerves.—The **arteries** supplying the Fallopian tubes come from the uterine and ovarian, each of which gives off a tubular branch, which passes in the one case outwards, in the other inwards, between the two layers of the meso-salpinx, and anastomose to form a single stem. The **veins** accompany the arteries. The **lymphatics** accompany those of the fundus uteri along the ovarian vessels, and terminate in the lumbar nodes. The **nerves** come from the hypogastric plexus, through the utero-vaginal.

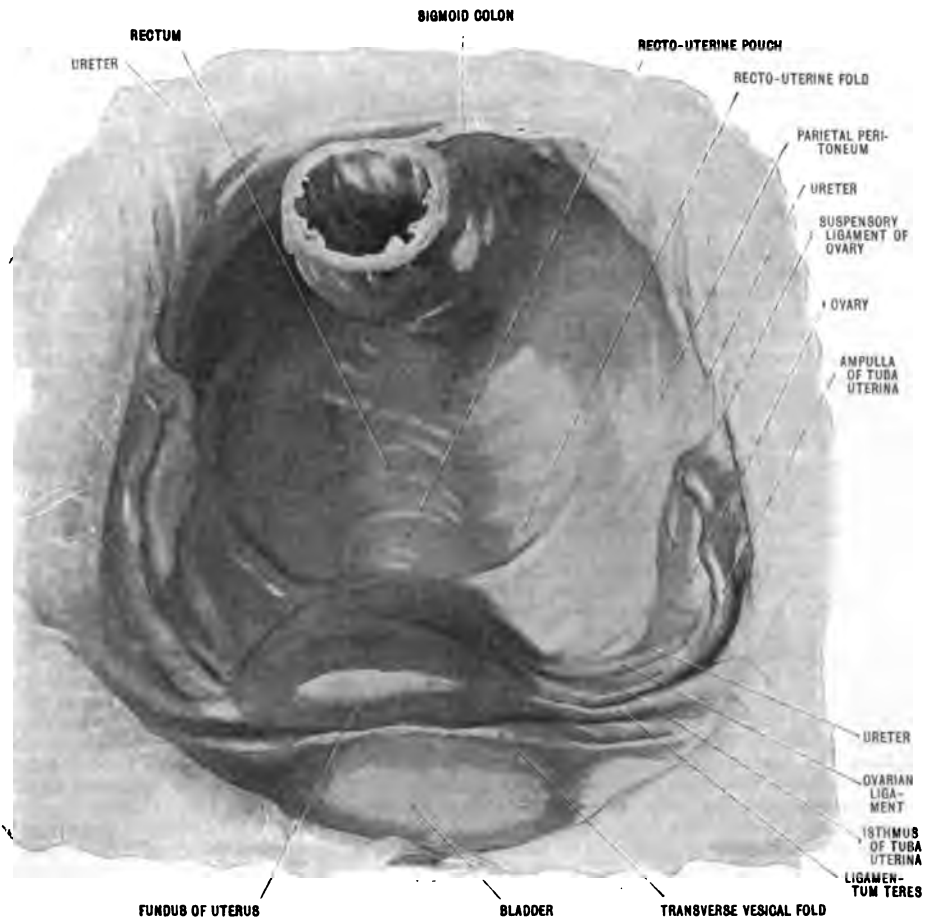
THE OVARIES

The **ovary** (figs. 861 and 885) is a paired organ which projects strongly from the posterior surface of the broad ligament. Its longest diameter measures from 3 to 5 cm. (1¼ to 2 in.), its greatest breadth 1·5 to 3 cm. (⅝ to 1¼ in.), its thickness about 0·5 to 1·5 cm. (⅕ to ⅗ in.); and its weight is ordinarily about 6 to 8 gm. The right is usually a little larger than the left.

Form, position, etc.—The typical shape resembles that of an almond, one border of which (the **mesovarial border**) is attached to the posterior layer of the broad ligament by the mesovarium, while the other is free. There has been much discussion as to the exact position of the ovary in the pelvis, and while the organ is apparently somewhat variable in this respect, what may be regarded as its typical

position is as follows. It lies almost in a sagittal plane (fig. 885) against the lateral wall of the pelvis, where it rests in a distinct depression, the **fossa ovarica,** bounded above by the external iliac vessels, behind by the ureter and uterine artery, and having in its floor the obturator vessels and nerve. The long axis of the ovary is almost vertical when the body is erect, the tubal extremity being upwards; its mesovarial border is directed forwards and outwards, its free border backwards and inwards towards the rectum, and its surfaces look almost outwards and inwards. (Waldeyer.) The ascending portion of the Fallopian tube rests upon its mesovarial border, and the fimbriated mouth of the infundibulum is in contact with the internal surface. When enlarged, the ovary may be felt through the vagina, and, better, through the rectum, and its position with regard to the surface is indicated by a

FIG. 885.—THE FEMALE PELVIC ORGANS VIEWED FROM ABOVE. (Spalteholz.)



point about midway between the anterior superior spine of the ilium and the symphysis pubis. The surfaces and free border are of a dull white, and after puberty are scarred by breaches of surfaces due to the dehiscence of ripe ova; the attached border is pierced by the ovarian vessels and nerves which lie between the layers of the mesovarium, and their point of entrance is termed the **hilus.**

The surface of the ovary is covered by a single layer of columnar cells, which become continuous with the peritoneal epithelium at the lines of attachment of the mesovarium. Its substance is a network of connective-tissue fibres, among which non-striped muscle-fibres also occur, and is known as the **stroma.** In the deeper or medullary portions of this the meshes of the network are largely occupied by blood-vessels, but in the cortical portions are multitudes of immature ova, surrounded by

their follicle cells, and also numbers of vesicles, the **Graafian follicles,** each of which contains an ovum in a more advanced stage of development.

As they ripen and approach the surface the Graafian follicles increase in dimensions, and may even attain the size of a large white currant. Their rupture leads to the scarring already mentioned, and the empty capsule slowly disappears when impregnation has not occurred; but under the influence of the vascularisation of the organs during pregnancy, it may undergo a remarkable development and form a yellow plicated body known as the **corpus luteum.**

Vessels and nerves.—The chief **artery** of the ovary is the ovarian, which, together with the ovarian veins and some lymphatics, passes to the ovary from the postero-lateral abdominal wall between the two layers of the broad ligament, forming what is termed the **suspensory ligament** of the ovary. An additional source of blood-supply is the ovarian branch of the uterine. The **veins** follow the arteries. As the ovarian veins emerge from the hilus, they form between the layers of the mesovarium a well-developed plexus (the **pampiniform plexus),** in the meshes of which numerous unstriped muscle-fibres occur, the whole having the appearance of an erectile organ. The **lymphatics** accompany the ovarian vessels to terminate in the lumbar nodes. **Nerves** pass to the ovary with the ovarian artery from the abdominal sympathetic plexuses.

DEVELOPMENT OF THE REPRODUCTIVE ORGANS

It has already been pointed out (p. 1167) that during development three different sets of excretory organs are developed. Of these, the middle set, the **meso-nephros** or **Wolffian body,** reaches a high degree of development, and its duct, the **Wolffian duct,** opens into a **cloaca** or common outlet for the intestinal and urinary passages. The meso-nephros forms a strong projection from the posterior wall of the abdomen into the body cavity, and on the medial surface of the peritoneum which covers it a thickening appears which is termed the **genital ridge.** The upper part of this ridge becomes the ovary or testis, as the case may be, while the remainder of it becomes the ovarian and round ligaments in the female and the gubernaculum testis in the male.

As the ovary or testis developes the tubules of the upper part of the Wolffian body enter into relation with it, forming, indeed, in the case of the testis, a direct union with the seminiferous tubules. The Wolffian body then becomes divisible into a reproductive and an excretory portion, and, when the meta-nephros or permanent kidney developes, the latter portion degenerates, leaving only a few rudiments, such as the paroöphoron in the female (p. 1201) and the vas aberrans and paradidymis (p. 1178) in the male. The reproductive portion also becomes much reduced in the female, persisting as the tubules of the epoöphoron (p. 1201), but in the male it forms the lobules of the epididymis and serves to transmit the spermatozoa to the Wolffian duct.

In addition to the Wolffian duct, a second duct, the **Müllerian,** occurs in connection with the genito-urinary apparatus, and, like the Wolffian duct, it opens below into the cloaca. The history of the two ducts is very different in the two sexes. In the **male** the Wolffian duct persists to form the vas deferens, of which the seminal vesicle is an outgrowth and the ejaculatory duct the continuation, while the Müllerian duct degenerates, its lower end persisting as the prostatic utriculus and its upper end as the appendix of the epididymis. In the **female,** on the contrary, it is the Müllerian duct which persists, its lower portion fusing with the duct of the opposite side to form the vagina and uterus, while its upper portion forms the Fallopian tube. Inhibition of the fusion of the lower ends of the two Müllerian ducts give rise to the bihorned or divided uteri, or the bilocular uteri and vaginæ which occasionally occur. The Wolffian duct in the female almost completely disappears, persisting only as the longitudinal tube of the epoöphoron and as the rudimentary canal of Gärtner (p. 1195). With the degeneration of the meso-nephros the peritoneum which covered it becomes a thin fold, having in its free edge the Müllerian duct and, in the fusion of the lower ends of the ducts the two folds also fuse and so give rise to the broad ligament.

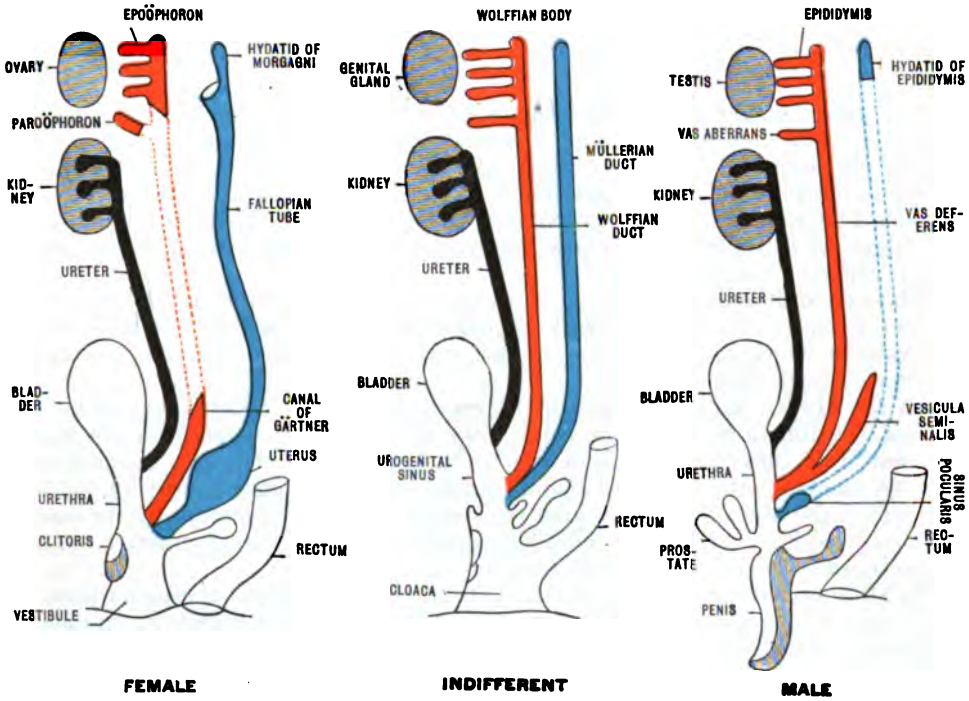
The developmental relations of the male and female organs may be seen from figure 886 and also from the following table:—

	MALE	FEMALE
Genital ridge	Testis	Ovary
	Gubernaculcum testis	Ovarian ligament Round ligament
Wolffian body	Head of epididymis	Epoöphoron
	Paradidymis Vas aberrans	Paroöphoron
Wolffian duct	Body and tail of epididymis	Longitudinal tubule of epoöphoron
	Vas deferens	Canal of Gärtner
	Ejaculatory duct	
Müllerian duct	Appendix of epididymis	Fallopian tube
		Uterus
	Prostatic utriculus	Vagina

The development of the external organs of generation in the two sexes presents a similar differentiation from a common condition. The division of the cloaca to form a **urogenital sinus** and the terminal part of the rectum has already been noted (p. 1174). In the floor of the sinus, to the sides of and above the urethral orifice, erectile tissue developes, forming a **genital tubercle.** An outpouching of that portion of the anterior abdominal wall to which the round ligament of the uterus or the gubernaculum was attached occurs to form the **genital swellings,** lying one on either side of the sinus, and internal to these a pair of folds develope at the borders of the sinus, enclosing the genital tubercle above and forming the **genital folds.**

This condition practically represents the arrangement which persists to adult life in the **female.** The genital tubercle becomes the clitoris, the genital swellings the labia majora, the genital folds the labia minora, and the urogenital sinus, into which the urethra and Müllerian ducts (vagina) open, is the vestibule. In the **male** the development proceeds farther. The genital tubercle elongates to form the penis, and the free edges of the genital folds meet together and fuse, closing in the urogenital sinus and transforming it into the cavernous portion of the

FIG. 886.—FEMALE REPRODUCTIVE ORGANS.



urethra, thus bringing it about that the male urethra subserves both reproductive and urinary functions. The genital swellings also meet and fuse together below the root of the penis, forming the scrotum.

The homologies of the parts in the two sexes may be seen from the following table:—

	MALE	FEMALE
Urogenital sinus	Cavernous portion of urethra	Vestibule
Genital tubercle	Penis	Clitoris
Genital folds	Integument and prepuce of penis	Prepuce of clitoris and labia minora
Genital swellings	Scrotum	Labia majora

Inhibition of the development of the parts in the male or their over-development in the female will produce a condition resembling superficially the normal condition of the opposite sex, and constituting what is termed *pseudo-hermaproditism;* or a failure of the genital ridges to fuse may result in what is known as *hypospadias*, the cavernous portion of the urethra being merely a groove in the under surface of the otherwise normal penis.

THE STRUCTURES AT THE PELVIC OUTLET

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The **pelvic outlet** is a lozenge-shaped space bounded in front by the symphysis and the arcuate (sub-pubic) ligament, behind by the tip of the coccyx, and on each side by the conjoined rami of the pubis and ischium, the tuber ischii and the sacro-tuberous (great sacro-sciatic) ligament. The latter structure is overlapped to a variable extent by the gluteus maximus, which also covers the tuber ischii when the thighs are extended. The glutei, however, are to be regarded as merely accessory to the true boundaries.

The **pelvic floor** is the name given to the whole of the soft structures that close the pelvic outlet. It forms a thick compact mass, traversed by clefts or canals the walls of which are usually in contact, but which open up for the passage of material through them.

In the human subject, in which the erect posture necessitates special modifications, the functions which the pelvic floor is called upon to perform are widely different from those in animals in which the long axis of the body is horizontal. In most mammals the weight of the abdominal viscera is largely borne by the ventral wall of the abdomen, but in man the weight is sustained mainly by the floor of the pelvic cavity, and this is accordingly specially modified to give active support to the burden which has been transferred to it.

In all mammals the closure of the clefts in the pelvic floor, through which the rectal and genito-urinary canals are transmitted, is brought about by the action of muscular fibres, and the compact mass forming the floor of the pelvis is therefore, even in its simplest form, partly muscular; the rest is made up of connective tissue and integument. The muscular fibres, which form a distinct layer in the pelvic floor, surround the canals which traverse the clefts, and they control or guard these canals at their outlet; in other words, the layer is largely sphincteric in action. It is obvious that a pelvic floor so constituted is not specially adapted for support.

But a great difference in the architecture of the pelvic floor is apparent in those mammals in which the long axis of the body is either absolutely or approximately vertical. In them the floor is further modified for the support of abdominal viscera, and, in addition to the layer of muscle controlling the clefts, another layer is developed in the form of a well-marked diaphragm, which constitutes a muscular sheet attached on all sides to the walls of the pelvic cavity. In the human subject this sheet includes the levatores ani and coccygei muscles.

The more highly differentiated pelvic floor, therefore, consists of a compact mass in which two distinct layers of muscles may be recognised, the arrangement and functions of which are in striking contrast. The upper layer, designed for purposes of support, forms a more or less complete "pelvic diaphragm"; the inferior layer, designed for purposes of control, forms sphincters for the openings of the canals which perforate the floor to reach the exterior.

The two layers are not only functionally but morphologically different. The sphincter muscular layer is derived from the primitive sphincter cloacæ, and though the muscles differentiated from it vary in the lower and higher types of mammals, they follow a general plan of organisation.

As regards the pelvic diaphragm it is interesting to find that although it con-

tributes to the support of viscera, the muscles which constitute it are derived from the flexors and abductors of the caudal end of the vertebral column. In tailed mammals this group of muscles passes from the side wall of the pelvis to the tail and moves that structure. But coincident with the assumption of the upright posture not only is the number of caudal vertebræ reduced, but the muscles which move them undergo similar retrogressive changes. This group is now available for other functions, and it eventually undergoes such modifications as to form the diaphragm, which is such an essential feature of the pelvic floor in man and some apes.

The muscles derived from the sphincter muscular layer are the sphincter ani externus, the transversus perinei superficialis, the bulbo-cavernosus, and the ischio-cavernosus. The muscles situated between the two fascial layers of the urogenital trigone (triangular ligament) are also derived from this layer, and include the constrictor urethræ membranaceæ, transversus perinei profundus, and the rudimentary ischio-pubicus.

The pelvic diaphragm includes the coccygeus, the ilio-coccygeus, and pubo-coccygeus muscles of each side. The ilio-coccygeus and the pubo-coccygeus, together, constitute the levator ani.

The pelvic diaphragm—first so named by Meyer—is somewhat funnel-shaped, but much deeper behind than in front. Indeed, it somewhat resembles in shape a horseshoe attached by its anterior extremities to the pubes and encircling the rectum behind, and perhaps this description is calculated to convey a more correct idea of its shape. Through the anterior part of the diaphragm are transmitted the rectum and urethra in the male; the rectum, vagina, and urethra in the female.

THE PELVIC FLOOR IN THE MALE

The integument is pigmented, beset with scattered hairs, and provided with large sebaceous and sudoriparous glands. The deeper layers contain an abundance of smooth muscular fibres continuous with the dartos of the scrotum, and these are so disposed around the anal margin as to corrugate the skin into radiating folds during their contraction (*corrugator cutis ani*).

The landmarks of the region are for the most part well defined. The symphysis in front is obscured by the root of the penis, which may be traced backwards in the middle line as a soft median prominence as far as a point 2·5 cm. (1 in.) in front of the anus. On each side the pubic and ischial rami may be felt running outwards and backwards to expand into the ischial tuberosity, which is uncovered by the gluteus maximus when the thigh is flexed. Extending backwards and inwards from the tuberosity may be detected, in thin subjects, the resistance of the sacro-tuberous (great sacro-sciatic) ligament; and still more posteriorly the coccyx is felt in the middle line immediately beneath the skin. The anal aperture surrounded by radiating furrows lies a short distance in front of the coccyx, and on each side of it is a depression called the **ischio-rectal fossa,** filled up by a pad of fat.

The term "central point of the perineum" is given to the tendinous area situated in the middle line between the anus and the posterior end of the bulb. It is to this structure that a number of muscles converge to obtain attachment, such as the transversus perinei superficialis, the sphincter ani externus, the bulbo-cavernosus and the pre-anal fibres of the levator ani (levator prostatæ).

The pelvic outlet is arbitrarily divided into two parts by a line drawn transversely between the two ischial tuberosities, an inch in front of the anus. The anterior portion, called the urethral triangle, transmits the urethra; the posterior portion transmits the rectum and is named the rectal triangle.

It will be convenient therefore to describe the more superficial structures in the pelvic floor, according to their disposition in one or other of these two triangles, and afterwards to describe the pelvic diaphragm—the deeper stratum of the pelvic floor—as a more or less complete muscular sheet stretching across the pelvic cavity, and pierced by the rectal and genito-urinary canals.

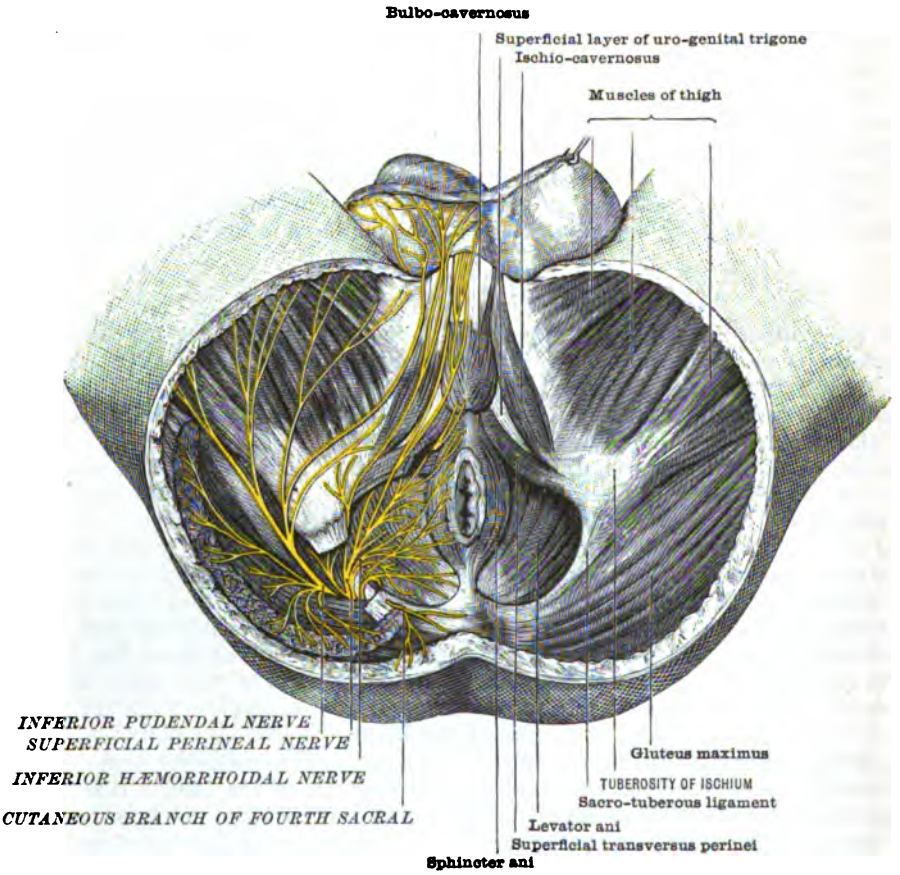
The **rectal triangle** contains, in addition to the rectum, the parts surrounding the anus, and the ischio-rectal fossæ. The removal of the integument exposes the sphincter muscle of the anus in the middle line, and on each side the mass of fat which fills in the ischio-rectal fossa.

The **external sphincter ani** (Figs. 887 and 894) is a muscular band about 2·5 cm.

(1 in.) deep which encircles the anal canal. It consists of layers of superimposed fibres, and along with the pubo-rectal portion of the levator ani, it forms a muscular cylinder by which the rectum is guarded at its outlet. The external sphincter muscle is elliptical in shape. In its most differentiated form three layers are distinguishable, but in some cases, and particularly in the female, there are only two separate layers. The three layers usually existing are appropriately named—(1) sphincter ani externus subcutaneus; (2) sphincter ani externus superficialis; (3) sphincter ani externus profundus.

(1) **Sphincter ani externus subcutaneus:** This division of the muscle is situated immediately beneath the skin. Its fibres surround the anal aperture and decussate in front of and behind that opening. Posteriorly, the fibres fail to reach the coccyx, but anteriorly they may be prolonged forwards to the scrotum. (2)

FIG. 887.—THE MALE PERINEUM. (Modified from Hirschfeld and Leveillé.)



Sphincter ani externus superficialis: As the superficial sphincter is the only layer which is attached to the coccyx, it is convenient to refer to it as the *coccygeal part* of the muscle. This connection with the caudal end of the vertebral column represents the primitive arrangement of the whole mass; in the case of the other layers the attachment has disappeared. It arises chiefly by means of a fibrous aponeurosis from the dorsal aspect of the terminal piece of the coccyx, though in some subjects the muscular fibres arise directly from the bone, and also from the ano-coccygeal raphé. Passing forwards the muscle increases in size and at the posterior margin of the anus it divides into two halves which come into contact on either side with the lower part of the anal canal. At their insertion some of the fibres become tendinous in the central point of the perineum, others pass superficially towards the skin, whilst many are continuous with the bulbo-cavernosus.

(3) **Sphincter ani externus profundus:** The deep division forms an annular band

of some thickness in contiguity with the pubo-rectal fibres of the levator ani. Its upper margin is not sharply defined, because the fibres intermingle to a certain degree with those of the levator ani, and the fibres of the two sides are continuous behind the rectum without being attached to the coccyx. The disposition of the fibres in front of the anus requires special consideration. In many cases the fibres of the deep division pass over to the opposite side in front of the anus, and are attached to the ascending ramus of the ischium. In others the fibrous tissue constituting the perineal body extends into the layer, and separates those fibres passing to the ischium from those in contact with the rectum. The fibres passing to the ischial ramus represent the transversus perinei, and obviously this muscle is closely associated with the deep layer of the external sphincter, and may be regarded as a part of it.

The external sphincter is in relation superficially with the integument, deeply with the internal sphincter (a thickening of the circular muscle of the rectum), and externally with the fat of the ischio-rectal fossa. By the tonic contraction of the three layers of the sphincter ani externus both the anus and the anal canal are kept closed. Although this action is carried out involuntarily, the muscle is under the control of the will, and the canal may be forcibly occluded if necessary. In this action the muscle is assisted by the pubo-rectalis (part of the levator ani) and the internal sphincter, though the latter is only to a very slight degree controlled by the will. Thus, by a voluntary act the expulsive force exerted by the walls of the rectum can be resisted, but only up to a certain point. When the pressure above becomes very great the strongest voluntary efforts directed to the contraction of the external sphincter may be overcome. An opposite action of the muscle may be brought into play at the last stage of defæcation. After inhibition of the reflex action of the sphincters, the pressure above forces the contents of the rectum through the anal canal. Towards the end of this movement the external sphincter along with the pubo-rectalis may be forcibly contracted, so that the muscle now assists and completes the action of the circular fibres of the rectum, that is to say, instead of retarding the progress of the contents of the bowel it assists in their extrusion. While this action is more apparent in the case of constipation, it may be carried out to a greater or less degree in every act of defæcation. When the anal canal is closed the external sphincter attains its greatest depth, and, further, it is flattened from side to side so that its length much exceeds its breadth. When the canal is dilated the muscle becomes more flattened in a vertical direction, and also more circular.

The external sphincter derives its **nerve-supply** from two sources—the pudic and the perineal branch of the fourth sacral. The latter supplies the coccygeal part of the muscle, whilst the pudic, through the inferior hæmorrhoidal, gives branches chiefly to the two layers which have no attachment to the coccyx. The branches from the inferior hæmorrhoidal can usually be found by raising the outer border of the superficial division of the muscle, and twigs can be traced through it into the subcutaneous layer. The **arterial supply** of the muscle is from the inferior hæmorrhoidal branches of the internal pudic artery; its **veins** of large size terminate in the inferior hæmorrhoidal and pudic veins, whilst its **lymphatics** open into the inguinal glands.

The **ischio-rectal fossæ** are two deep interspaces, one on each side, left by the divergence of the obliquely directed muscles of the pelvic floor (levator ani and coccygeus) from the vertical pelvic wall. Each fossa is bounded *externally* by the obturator internus below the level of the tendinous arch of the levator ani, the corresponding portion of the obturator fascia (with Alcock's canal and the pudic vessels and nerves), and the os innominatum; *internally* by the levator ani, coccygeus and the anal fascia. Superiorly, the vertical outer wall is joined by the sloping inner wall where the anal fascia joins the obturator fascia, so that the space is angular $\wedge$ in outline in frontal section.

If the finger be introduced into the anterior part of the fossa, it will meet the line of junction of the triangular ligaments with the superficial fascia of the perineum; and above this will be found an **anterior recess** of considerable size extending forward nearly as far as the symphysis, between the superior layer of the urogenital trigone (triangular ligament) and the under surface of the levator ani, limited internally by the prostate and pubo-prostatic ligaments, and externally by the pubic and ischial rami. At the back part of the space will be felt the border of the sacro-tuberous (great sacro-sciatic) ligament, and above this a **posterior recess** running backwards for a variable distance towards the sacrum. Both of these deep exten-

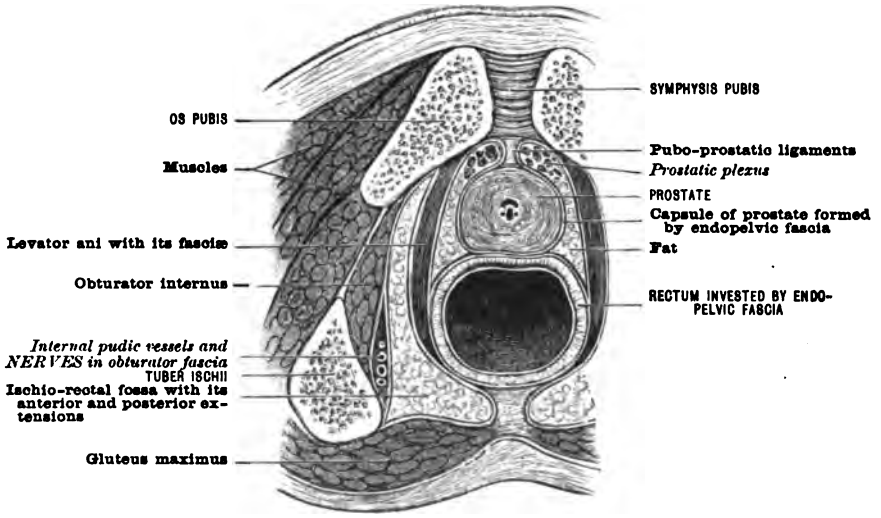
sions are lined by the anal and obturator fasciæ, and filled with fat and connective tissue.

Contents.—The ischio-rectal fossa is filled with loose adipose tissue continuous with the subcutaneous fat of the buttock, and traversed from without inwards by the inferior hæmorrhoidal branches of the internal pudic artery, by the associated veins and by the inferior hæmorrhoidal branches of the pudic nerve passing to the external sphincter ani, the adjacent skin and mucous membrane. The superficial perineal vessels and nerves as they run forward to pierce the superficial perineal fascia lie in the space, as well as the inferior clunial (perforating cutaneous) branches and perineal branches of the fourth sacral nerve.

The inferior hæmorrhoidal veins are usually somewhat dilated near the anal margin, and when morbidly enlarged constitute the condition known as hæmorrhoids or piles.

The **urethral triangle,** considered apart from the portion of the common integument which covers it in, is a curious triangular ledge of tissue stretched almost horizontally across the angular interval between the two ischio-pubic rami. It is pierced by the urethra (and also by the vagina in the female), and comprises three strong fasciæ which enclose within two interfascial spaces, the root of the penis with the muscles associated with it, the compressor urethræ membranaceæ muscle,

FIG. 888.—SECTION SHOWING THE ISCHIO-RECTAL FOSSA IN ITS RELATIONS TO THE PELVIC VISCERA. (W. A.)



the bulbo-urethral (Cowper's) glands, and a number of vessels and nerves. Above it lie the prostate and levatores ani with their fasciæ, and the anterior recess of each ischio-rectal fossa.

The integument has already been described. On removal of the skin with its dartos and the superficial layers of superficial fascia, a deeper plane of fascia will be exposed, connected firmly with the ischio-pubic rami. This is the **superficial perineal fascia (fascia of Colles),** the most superficial of the three true perineal fasciæ.

The **superficial perineal fascia** is a fibrous lamina of considerable strength. It is attached on each side to the lower margin of the ischio-pubic ramus and to the ischial tuberosity; behind, it turns around the posterior border of the superficial transversus perinei muscle to fuse with the posterior borders of the superficial and deep layers of the urogenital trigone (triangular ligament) and form the free border of the so-called 'perineal ledge'; anteriorly, it becomes continuous with the external fascial investment of the scrotum and the fascial covering of the penis.

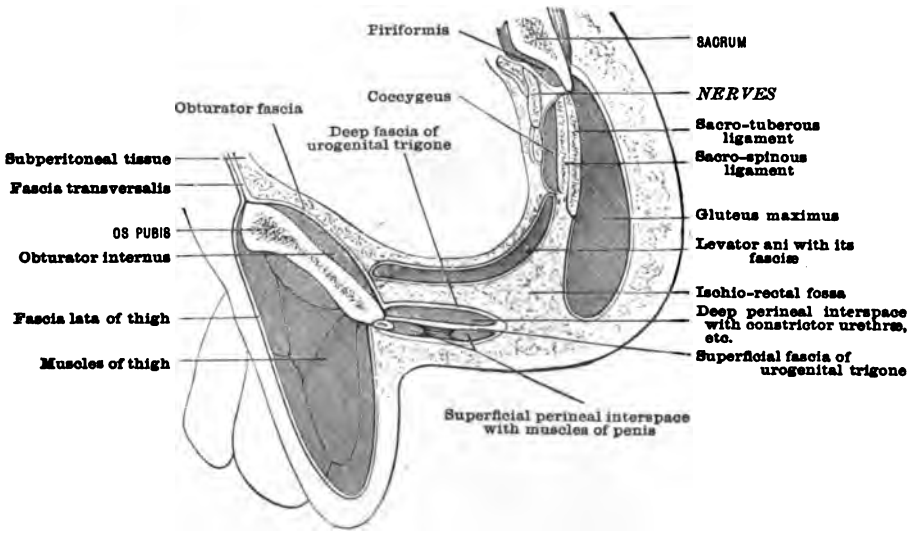
It is between this layer and the inferior layer of the urogenital trigone (triangular ligament) that extravasation of urine is especially prone to occur in rupture of the urethra. From its connections it will be seen that the extension of the fluid would be arrested posteriorly and laterally by the connection of the superficial perineal

fascia with the urogenital trigone and with the ischio-pubic rami; but it spreads freely beneath the integuments of the scrotum and of the penis as far as the neck of the glans, and to the surface of the abdomen. On the trunk, it may run in an upward direction even to the axilla, but it is prevented from descending below the groin by the connection of the abdominal fascia with the inguinal (Poupart's) ligament and to the margin of the fossa ovalis (saphenous opening) of the fascia lata.

Superficial perineal interspace.—Detaching the superficial perineal fascia from its connections, the dissector opens the superficial interfascial space and exposes its contents, namely:—(1) The **crura** of the corpora cavernosa penis with the **ischio-cavernosi**; (2) the **bulb** of the corpus spongiosum with the **bulbo-cavernosi**; (3) the capriciously scattered fibres of the **superficial transversi perinei**; (4) the **deep** and the **dorsal arteries of the penis** with their associated **veins** and **lymphatics**; (5) the **dorsal nerves of the penis**; and (6) the **perineal vessels and nerves**; (7) the **perineal** (long pudendal) **branches** of the posterior femoral cutaneous (small sciatic) nerve. The roof of the space (the so-called floor) is formed by the inferior layer of the urogenital trigone (triangular ligament).

The **deep artery of the penis** enters the crus immediately after piercing the inferior layer of the urogenital trigone; the **dorsal artery of the penis**, reaching

FIG. 889.—SAGITTAL SECTION THROUGH THE UROGENITAL TRIGONE AND ISCHIO-RECTAL FOSSA TO THE LEFT OF THE MIDDLE LINE. (Diagrammatic.) (W. A.)



the interfascial space more anteriorly with the dorsal nerve, runs forwards to the dorsum of the united corpora cavernosa to take its place between the vein and nerve; the **perineal vessels and nerve**, given off from the internal pudic trunks in the ischio-rectal fossa, enter the interfascial space near the free border of the perineal ledge, and divide into two sets of branches, the posterior or deep, to the penile muscles, and the anterior or superficial to the scrotal and perineal integument; the latter piercing the superficial perineal fascia (fascia of Colles) and the scrotal investment continuous with it to reach the skin.

The bulb and the crura of the penis have been already described (pages 1184, 1185). The muscles associated with them, each of which has a fascial sheath of its own distinct from the superficial perineal fascia, may now be examined.

The **bulbo-cavernosus** is composed of two lateral parts. These, which are usually but not invariably symmetrical, are united medially by a sagittal tendinous raphé. The raphé indicates the line of union of the originally separate halves of the muscle, and from it fibres arise on each side. Each half consists of layers of muscular fibres superimposed upon each other, surrounding the bulb of the penis, the hinder part of the corpus spongiosum, and in many cases, by a narrow band of the most anterior fibres, the body of the penis also.

In its most differentiated form four distinct layers of fibres may be distinguished,

but either from non-development of one or more, or as the result of fusion, the number is very frequently less. The arrangement may be unsymmetrical so that four layers may be present on one side and only two or three on the other.

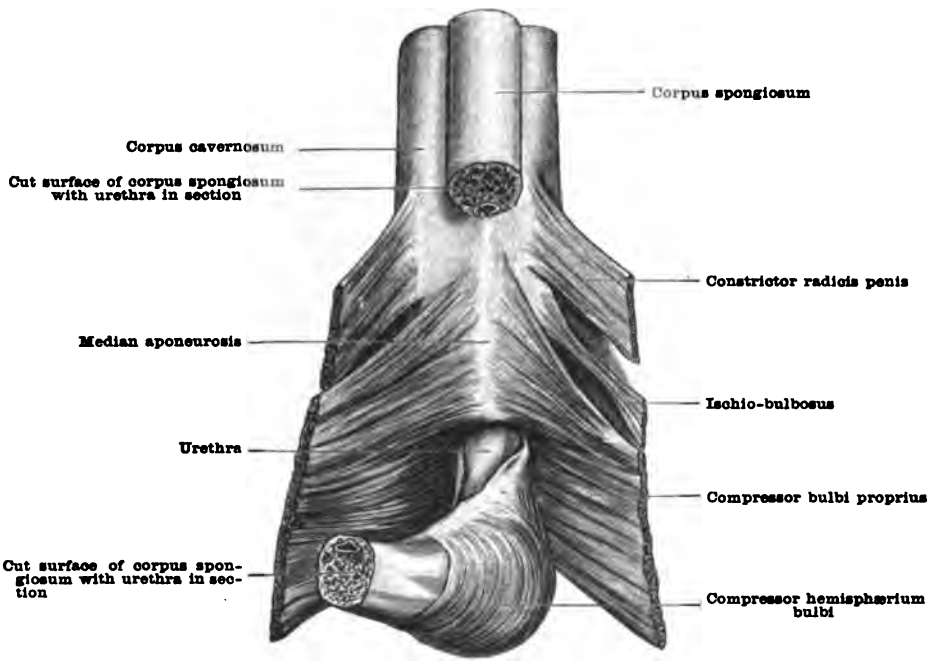
The four layers are named as follows: (1) Ischio-bulbosus; (2) constrictor radicis penis; (3) compressor bulbi proprius; (4) compressor hemisphærium bulbi.

(1) **The Ischio-bulbosus.**—This muscle arises either from the inner surface of the ischial tuberosity or from the ascending ramus of the ischium. It is directed obliquely inwards and forwards to the bulb of the penis, upon which its fibres spread out into a thin layer which covers the compressor bulbi proprius. The fibres terminate anteriorly either in the median raphé or by joining with those of the subjacent layers. In those subjects in which the muscle shows exceptional development the fibres can be followed beyond the bulb, where they terminate on the outer surface of the corpus cavernosum.

(2) **Constrictor radicis penis.**—Although the second and third divisions are for the most part in the same plane, fibres of the constrictor radicis may occasionally be observed extending backwards to the central point of the perineum superficial to the compressor bulbi. For this reason the constrictor radicis is described as a separate layer. The fibres are commonly united at the median raphé with those of the compressor bulbi, but towards their insertion they are

FIG. 890.—BULBO-CAVERNOSUS IN THE MALE.

The two halves have been reflected from the median raphé, and the bulb turned downwards after division of the corpus spongiosum. (The ischio-bulbosus is not present on the right side.)



quite distinct. In the few cases in which the muscle can be traced on to the dorsum of the penis, and to the subcutaneous tissue in front of the pubis, it may have a separate course for 10 or even 15 cm. (4 or 6 in.). It takes origin from the side of the median tendinous raphé for the anterior third or fourth of its extent. The fibres are directed forwards, upwards, and outwards; they diverge from those of the opposite side at an acute angle, and in some cases partially and in others wholly encircle the root of the penis by a narrow band of muscular fibres about half an inch broad. The insertion takes place in one of two ways. The fibres either end tendinously on the lateral surface of the corpus cavernosum penis immediately anterior to the insertion of the ischio-cavernosus, or they pass on to the dorsum of the penis, and, gradually losing their muscular character, terminate in a flattened fibrous expansion covering the dorsal vessels and nerves, which may finally be traced to the subcutaneous tissue in front of the body of the pubis.

(3) **Compressor bulbi proprius.**—This division is situated immediately behind the preceding and arises from the central point of the perineum where fibres are continued into it from the external sphincter ani and the transversus perinei superficialis. and from the side of the median tendinous raphé for the posterior two-thirds or three-fourths of its extent. The fibres are directed upwards and slightly forwards, covering the inferior and lateral surfaces of the bulb and adjacent part of the corpus spongiosum. The hindmost fibres gain insertion into the inferior surface of the urogenital trigone. The succeeding ones, and these comprise the anterior and larger part of the layer, encircle the corpus spongiosum, and on its dorsal surface meet with

the fibres from the opposite side to form a fibrous aponeurosis. The aponeurosis is situated between the corpus spongiosum and the united crura of the penis, and is firmly attached to the three parts of this body. But whereas the corpus spongiosum may be dissected from the aponeurosis without much difficulty, the union of the latter with the two crura, especially in the middle line, is much more intimate. The parts are so fused together that a separation can only be made artificially. It is evident, therefore, that the compressor bulbi proprius covers those parts only of the bulb of the penis which are not in direct contact with the urogenital trigone. On the other hand, it surrounds the adjacent part of the corpus spongiosum entirely.

(4) **Compressor hemisphærium bulbi.**—This forms the deepest layer of the bulbocavernosus. It is a ring-shaped muscle consisting of two symmetrical halves investing the free rounded end of the bulb of the penis. It lies immediately subjacent to the compressor bulbi proprius, and a distinct layer of connective tissue intervenes between them.

The fibres take origin from a median tendinous raphé situated on the posterior curvature of the bulb. The superior fibres, namely, those immediately beneath the urogenital trigone, are directed almost horizontally forwards, the middle, arising from the raphé lower down, ascend obliquely over the lateral aspect of the bulb, whilst the inferior are directed outward and then almost vertically upwards. All the fibres converge to a flat, narrow, and usually indistinct median tendon situated on the dorsal surface of the bulb of the penis, immediately in front of the point at which the membranous urethra sinks into the substance of the bulb. As Kobelt pointed out, the muscle surrounds the hemispheres of the bulb in the form of a closely fitting cap.

Action and Nerve-supply.—The name given by the earliest anatomists, of accelerator urinæ et seminis, indicates its functions. It acts as a compressor of the bulbous portion of the urethra and thus assists in the ejaculation of the semen, continuing the action of the ejaculating fibres of the prostate and of the deep transverse perinei, and it may also be of service in expelling the last drops of the urine. Another point deserves special mention, viz., the action of the compressor hemisphærium bulbi. Whilst there can be little doubt that its chief action is exerted on the lateral surface of the bulb, it is important to note that the urethra may be compressed at the point where it is sinking into the substance of the bulb by the dorsal tendon which unites the two halves of the muscle.

Several branches from the perineal division of the pudic nerve enter the bulbocavernosus and supply its various parts. Of these, the nerve to the constrictor radicis penis may be traced in many cases between the bundles of the compressor bulbi proprius, and is remarkable on account of its length. The branch to the compressor hemisphærium bulbi runs for a short distance, before entering its muscle, in the layer of tissue immediately under the compressor bulbi proprius.

The **ischio-cavernosus (erector penis)** muscle embraces the crus penis and extends along the margin of the pubic arch from the ischial tuberosity behind, to the lateral aspect of the penis in front. It is usually about 10 cm. (4 in.) long, but if, as sometimes is the case, the fibres are prolonged backwards on to the sacro-tuberous (great sacro-sciatic) ligament, or forwards on to the dorsum of the penis, its length is even greater. The ischio-cavernosus is flattened somewhat at its origin from the ischial tuberosity, but where the muscle invests the corpus cavernosum its sectional appearance is crescentic. The lower part of the ischio-cavernosus is chiefly muscular, its upper part markedly tendinous, and the general arrangement of the muscular fibres is such that they form remarkably slender bundles, many of them nearly 5 cm. (2 in.) long.

The ischio-cavernosus arises from the inner surface of the tuberosity of the ischium and in many cases from the sacro-tuberous (great sacro-sciatic) ligament. Also, from the conjoined rami of the ischium and pubis on each side of the attachment of the crus penis. It is inserted chiefly by means of a tendinous expansion, which is spread over the free surface of the crus, into the under and outer sides of that body at its front part near the point of attachment of the suspensory ligament.

A slip, the **pubo-cavernosus** or **levator penis,** is occasionally detached from the foremost part of the muscle and passes on to the dorsum of the penis. When present it arises from the descending ramus of the pubis and passes on to the dorsum of the penis, where the fibres are lost in the subcutaneous tissues. The fibres may in some cases meet with those of the opposite side to form a median tendinous expansion which covers the dorsal vessels, and accordingly this slip is usually called the **compressor venæ dorsalis.** There is evidence, however, to show that the slip does not correspond with the compressor venæ dorsalis penis of carnivora, but is homologous with the levator penis found in many of the lower animals. The compressor of the dorsal vein of the penis is represented in man by a vestigial muscle situated between the two layers of the urogenital trigone (triangular ligament) and named the **ischio-pubicus** (Vlacovitch).

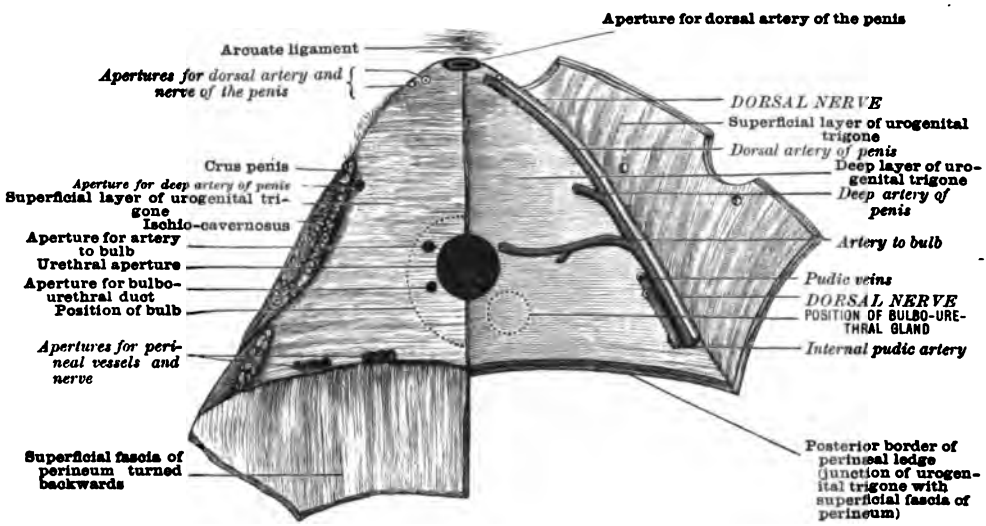
The ischio-cavernosus in the absence of its dorsal fasciculus can scarcely justify its older name of erector penis, but it appears to have the power of impressing voluntary movements upon the turgid organ.

Transversus Perinei Superficialis.—Under this name is included a number of muscular fibres, varying in arrangement, situated transversely between the ascending ramus of the ischium and the central point of the perineum. It is only in comparatively few subjects that the muscle is strongly developed. More frequently, it is represented by one or more feeble muscular slips, or by a few aponeurotic fibres, whilst in a number of cases it fails entirely. The muscle gains attachment to the ascending ramus of the ischium by tendinous fibres, situated either superficial or deep to the ischio-cavernosus. Also, to the base of the urogenital trigone, a short distance in front of the line of union with the superficial perineal fascia. Occasionally, a few fibres are attached to the interlobular fibrous septa over the tuber ischii or the anterior part of the ischio-rectal fossa.

At the central point of the perineum its connections must be specially noticed since the muscle is usually described as terminating there, and uniting with the corresponding muscle of the opposite side. Although this arrangement may be observed in many cases, in others an altogether different disposition is shown.

It has already been pointed out in describing the external sphincter, that in some cases the deep layer of that muscle was continuous with the transversus perinei of the opposite side, whilst in others the continuity was interrupted by the perineal body, with which each muscle appeared to be connected. Occasionally,

FIG. 891.—DIAGRAM OF THE SUPERFICIAL AND DEEP LAYERS OF THE UROGENITAL TRIGONE.



a few fibres become detached from the transversus perinei between the perineal body and the ischium, and join with the bulbo-cavernosus or the external sphincter of the same side.

Action and Nerve-supply.—It is usually stated that when the transversi perinei contract, the central point of the perineum is fixed, and that this favours the contraction of the bulbo-cavernosus. It thus acts as an accessory muscle in emptying the urethra. But, as we have previously seen, the muscle is frequently absent in man, and altogether unrepresented in many of the lower mammals. Its absence, however, does not appear to exercise any adverse influence on the efficiency of either the external sphincter ani, or the bulbo-cavernosus. Indeed, it is difficult to see how its action can be of much importance, and, when present, although it may take an active part in the genito-urinary functions, its intervention is probably not essential.

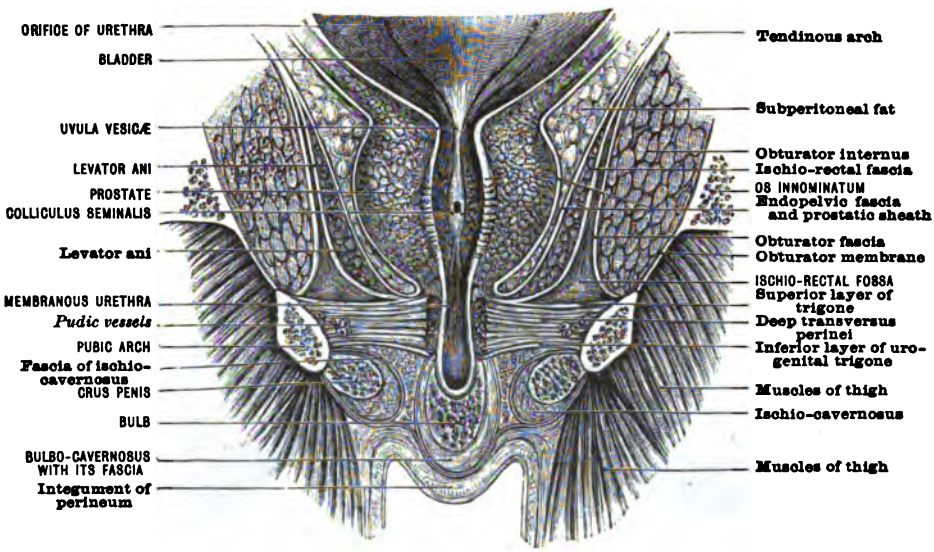
The transverse muscle usually derives a branch from the perineal division of the pudic nerve, as this courses along its posterior border. The superficial perineal interspace, known also as the **perineal pouch,** may therefore be said to contain the root of the penis, with the muscles, vessels, and nerves associated with it.

The urogenital trigone.—The floor, or what is really the roof of the superficial perineal interspace, is formed by the **urogenital trigone** (**urogenital diaphragm** or **triangular ligament**), composed of two strong layers of fascia, at-

tached in front and at the sides to the pubis and ischio-pubic rami and united behind, thus enclosing a deep perineal interspace. The central portion of the urogenital trigone fills in the space between the two pubo-coccygei muscles, completing the pelvic floor and giving passage to the urethra.

The **inferior layer of fascia of the urogenital trigone (superficial or inferior triangular ligament).**—On removing the contents of the superficial interspace the dissector exposes the under surface of the inferior layer of fascia of the urogenital trigone. This structure forms almost a horizontal plane in the erect posture of the body, and consists of strong bands of fibrous tissue, running for the most part in a transverse direction across the subpubic arch to be attached firmly to a ridge on the ischio-pubic rami, above the line of attachment of the superficial perineal fascia and of the penile muscles. Anteriorly, it is separated from the arcuate (sub-pubic) ligament by an interval which transmits the dorsal vein of the penis; posteriorly, it blends with the superficial perineal and with the superior layer of the urogenital trigone to form the hinder border of the perineal ledge; and superiorly it is intimately related to the deep transversus perinei muscles. It is pierced by:—(1) the urethra, about an inch and a quarter below the symphysis; (2) the ducts of the bulbo-urethral (Cowper's) glands, one on each side of the posterior part of

FIG. 892.—VERTICAL FRONTAL SECTION OF THE PELVIS, SHOWING FASCIÆ.
(Modified from Braune.)



the urethral openings; (3) the arteries of the bulb, somewhat external to the last; (4) the internal pudic arteries, more anteriorly; (5) the dorsal nerves of the penis, just external to the internal pudic arteries; (6) the perineal vessels and nerves and often the urethral (transverse perineal) artery, all piercing the ligament near the base. The dorsal vein of the penis, with some accompanying lymphatics, runs through the interspace between the trigone and the arcuate (sub-pubic) ligament.

Near the apex of the urogenital trigone is a more or less distinct band, passing transversely from one side of the pubic arch to the other, and known as the **transverse pelvic ligament.** This ligament is probably the remains of the tendon of a muscle, the ischio-pubic muscle, well developed in some mammals, but rudimentary in man, whilst the urogenital trigone itself is probably a development of the fascia transversalis.

Deep perineal interspace.—If the anterior layer of the urogenital trigone (triangular ligament) be now detached, the deep perineal interspace will be laid open. This space is somewhat wedge-shaped in sagittal section, in consequence of the manner in which the two layers of the trigone approach each other before their union at the posterior border of the perineal ledge. It is occupied by the following structures, which may therefore be said to lie between the two layers of the trigone.

(1) The **membranous urethra,** surrounded by its annular sphincter of smooth muscular fibres.

(2) The **bulbo-urethral (Cowper's) glands,** seen as two white pea-like bodies, one on each side of the posterior segment of the urethra. Their ducts pierce the anterior layer of the trigone.

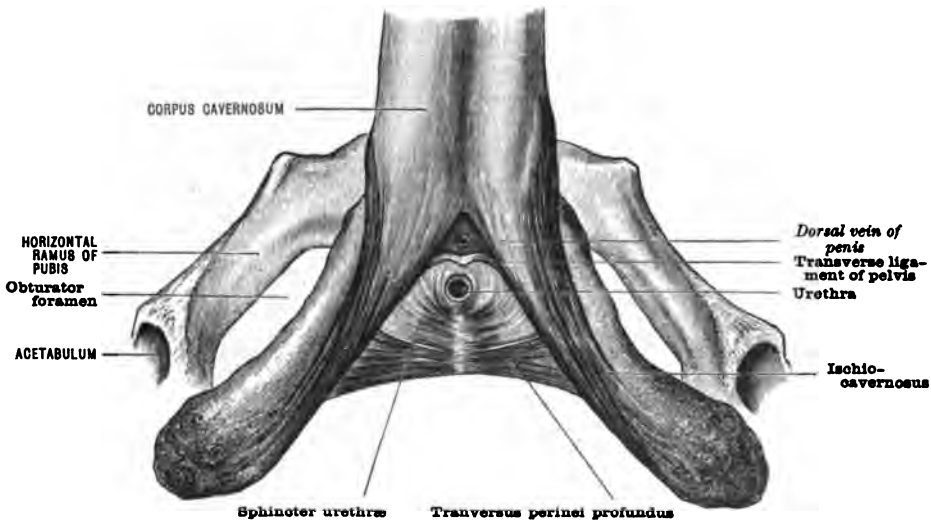
(3) The **internal pudic arteries,** lying close to the ischio-pubic rami imbedded in the fibres of origin of the sphincter urethræ membranaceæ muscle, giving off each an artery to the bulb as well as some twigs to the bulbo-urethral gland and to the muscular tissue surrounding the urethra, and terminating by division into the deep and the dorsal arteries of the penis. These branches with the associated veins have been seen to pass through the inferior layer of the trigone into the superficial perineal interspace.

(4) The **pudic veins,** accompanying the arteries. Their tributaries form a plexus around the urethra, and in the substance of the fibres of the deep transversus perinei. This plexus, which is often largely developed in old persons, receives the veins of the corpus spongiosum and corpora cavernosa, and communicates freely with the dorsal vein of the penis, and through this with the prostatic plexus.

(5) The **pudic lymphatics,** accompanying the veins and terminating in the pelvic glands.

(6) The **dorsal nerves of the penis,** the terminal branches of the internal

FIG. 893.—MUSCLES BETWEEN THE TWO LAYERS OF THE UROGENITAL TRIGONE (MALE).



pudic nerves, accompanying the pudic arteries; each nerve gives off filaments to the transversus perinei profundus and the sphincter urethræ membranaceæ muscles, finally piercing the forepart of the inferior layer of the urogenital trigone with the pudic artery.

(7) Three muscles: (*a*) The sphincter urethræ membranaceæ; (*b*) The transversus perinei profundus; (*c*) The rudimentary ischio-pubicus.

(*a*) The **sphincter urethræ membranaceæ** muscle, situated between the two layers of the urogenital trigone, consists of a series of fibres which present different relations and perform different functions. Whilst many fibres extend transversely or obliquely across the pubic arch, others, which reach upwards as far as the prostate, surround the membranous urethra in a circular manner.

It will be convenient, therefore, to describe two distinct groups of fibres. One group extends transversely or obliquely across the pubic arch, a few fibres in front of, but the majority behind the membranous urethra. The other group is arranged circularly around the membranous urethra and extends a variable distance towards the prostate. In fact, Holl describes fibres of this muscle lying on the lateral aspect of the prostate and forming a *sphincter muscle of the prostatic urethra.*

The transverse fibres arise from the descending ramus of the pubis, from the two layers of the urogenital trigone between which they are situated, and from the back of the transverse

ligament of the pelvis. They converge around the urethra towards the middle line, where they meet with the fibres from the opposite side and form a median tendinous raphé, though in some cases the fibres on the two sides are uninterruptedly continuous. Comparatively few fibres pass in front of the urethra.

The true sphincter fibres are arranged around the membranous urethra in the form of a muscular sheath. According to Holl, they are disposed in a series of layers, in some of which the fibres run circularly, in others longitudinally. In new-born children this arrangement is very characteristic, as shown by Cadiat by means of microscopical sections of the perineum. He found that the urethra from the neck of the bladder up to the bulb is surrounded by a cylinder of muscular fibres of which some are striated, others smooth; at many points the elements are intermingled.

(*b*) The **transversus perinei profundus** is situated at the lower and posterior edge of the sphincter urethræ membranaceæ and in a plane above and in front of the transversus perinei superficialis. The fibres arise from the neighbourhood of the point of union of the pubic and ischial rami, and, passing inwards to the middle line, are inserted into a median raphé, situated between the muscles of the two sides. The median raphé closely adjoins the one formed by the union of the two halves of the transverse fibres of the constrictor urethræ.

(*c*) The **ischio-pubicus** is a rudimentary muscle which arises from the conjoined rami of the pubis and ischium ventral to the attachment of the sphincter urethræ membranaceæ. Passing forwards it terminates in a flat tendon which is directed across the pubic arch and unites with the tendon from the opposite side under the dorsal vein of the penis.

Although the main part of the muscle is frequently absent, or replaced by fibrous tissue, the united tendons of the two muscles can nearly always be recognised. They form in many cases a well-defined fibrous band situated near the upper margin of the urogenital trigone, of which, under the name of transverse ligament of the pelvis, it is usually regarded as a thickening. There seems little doubt, however, that this muscle is the representative in man of the compressor venæ dorsalis penis present in many of the lower animals.

The action of the sphincter urethræ membranaceæ is partly to compress the membranous urethra and thus assist the expulsion of urine and semen, and partly to intercept the flow of blood through the veins of the penis, and so aid in erection. It also exercises compression upon the bulbo-urethral glands, and effects the discharge of their secretion during seminal emission. It is supplied by a branch from the dorsal nerve of the penis.

The **superior layer of fascia of the urogenital trigone** (**deep** or **superior triangular ligament**) is in some sort a prolongation of the obturator fascia across the pubic arch, the continuity of the two fasciæ, however, being interrupted by the attachment of their deep fibres to the inner edges of the ischio-pubic rami. Inferiorly it is in intimate relation with the three muscles described above; while superiorly it forms on each side the floor of the anterior extension of the ischio-rectal fossa; and in the middle line it is separated from the apex of the prostate by a prolongation of the endopelvic (recto-vesical) fascia, and by a layer of smooth muscular fibre, the **prerectalis** of Henle, in which end the greater part of the anterior longitudinal fibres of the rectum.

The Pelvic Diaphragm

The **diaphragma pelvis** (Meyer) or *diaphragma pelvis rectale seu proprium* (Holl) is formed by two muscles from each side of the pelvis, the levator ani and the coccygeus. The levator ani is composed of two parts, named the ilio-coccygeus and the pubo-coccygeus. They are homologous with the ilio-caudalis and pubo-caudalis, two muscles, found in nearly all tailed animals, which act as flexors of the tail.

In the human subject the **levator ani** arises along an uninterrupted line from the back of the body of the pubis, from the pelvic fascia on the side wall of the pelvis and from the spine of the ischium. Its fibres are inserted into the coccyx and the ano-coccygeal ligament, whilst a few pass to the central point of the perineum. It is clear, therefore, that most of the fibres at their insertion are post-anal.

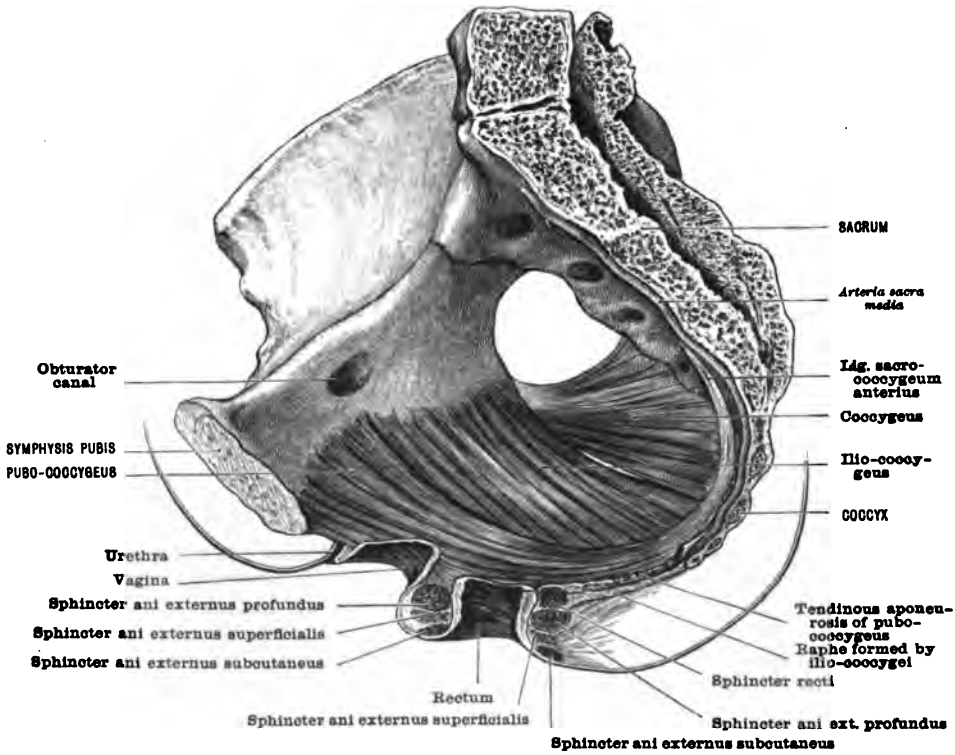
It is not always easy, but usually possible, to find the interval between the part arising from the pubis and the part arising from the pelvic fascia, since in most cases the adjoining edges of the two muscles overlap one another. It was this interval which led Lartschneider to describe two parts of the levator ani, a *portio*

pubica and a *portio iliaca*, and Savage to speak of *pubo-coccygeus* and *obturato-coccygeus*. It seems preferable, however, to refer to the two muscles as pubo-coccygeus and ilio-coccygeus, which at once suggests their homology with the corresponding muscles in tailed animals.

The **ilio-coccygeus** arises from the pelvic fascia and from the inner aspect of the spine of the ischium. Its attachment to the pelvic fascia is along a curved line whose concavity is directed upwards. The line has a varying relation to the side wall of the pelvis; in some cases it is situated almost as high as the obturator canal, and in other cases considerably below it. Posteriorly the origin of the ilio-coccygeus extends as far as the margin of the great sacro-sciatic notch, whilst anteriorly it reaches almost as far as the commencement of the obturator canal.

The line of origin of the ilio-coccygeus just described does not completely coincide with the tendinous arch ('white line') of the pelvic fascia. Posteriorly they may coincide, but in front the 'white line' occupies a lower level, and is situated on the fibres of the ilio-coccygeus as a thickening of the endopelvic fascia. The line of origin of the ilio-coccygeus from the pelvic fascia is known as the *arcus tendineus musculi levatoris ani*, to distinguish it from the white

FIG. 894.—SAGITTAL SECTION OF THE PELVIS TO SHOW THE PELVIC DIAPHRAGM AND EXTERNAL SPHINCTER ANI.



line of the pelvic fascia (i. e. the external line of attachment of the endopelvic fascia), named the *arcus tendineus fasciæ pelvis*.

From their origin the fibres of the ilio-coccygeus are directed downwards, backwards, and inwards to the coccygeal vertebræ. They are inserted from behind forwards into the lateral margin of the last two pieces of the coccyx, into the tip of the coccyx, and into a median raphé which runs from the tip of the coccyx to the posterior margin of the anus, the ano-coccygeal ligament The most posterior (i. e. dorsal) fibres may be represented by a separate and distinct muscle, known as the **ilio-sacralis** (see fig. 902).

The **pubo-coccygeus** arises from the back of the body of the pubis along an oblique line which extends from the lowest limit of the symphysis upwards and outwards towards the obturator canal. Also, from the obturator fascia for a limited extent along a line continued forwards from the origin of the ilio-coccygeus. To follow the insertion of the muscle more readily it is convenient to divide the pubo-coccygeus into three parts: (*a*) the upper stratum (pubo-coccygeus proper), (*b*) the lower stratum (sphincter recti), and (*c*) the levator prostatæ (pre-anal fibres of the levator ani).

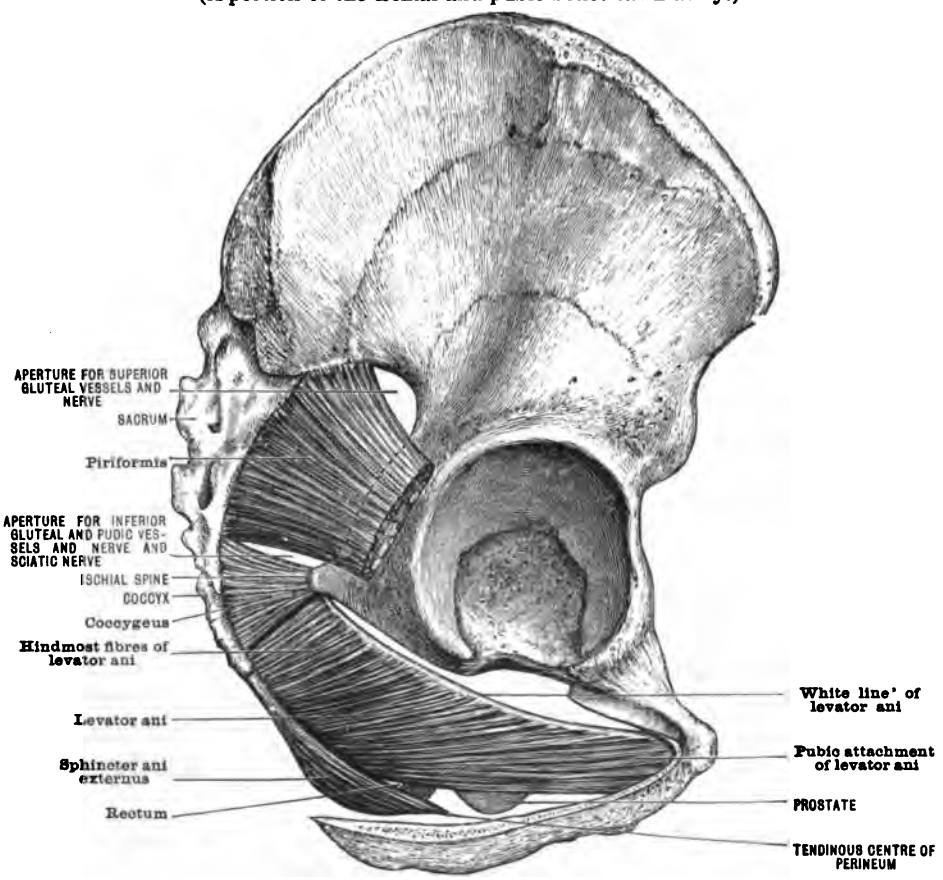
(*a*) The upper stratum forms a flat band about an inch wide, thick at its mesial border, thin where it overlaps the ilio-coccygeus. It is directed backwards, almost horizontally along the side of the anal canal towards the coccyx and sacrum, to which it obtains attachment. Behind the rectum the two pubo-coccygeal strata come together to form a thick fibro-muscular layer, and it is this layer which is prolonged upwards as a well-marked aponeurosis, to obtain

attachment to the front of the sacrum and coccyx. The prolongation upwards is divided into two lateral portions, situated one on either side of the middle sacral artery and named the *ligamenta sacro-coccygea anteriora*. The ligaments are finally inserted into the fourth and fifth pieces of the sacrum and the first piece of the coccyx.

(*b*) The lower stratum or *sphincter recti* is so arranged as to form a muscular sling around the lower part of the rectum, and may be regarded as a part of the pubo-coccygeus which has lost its connections with the vertebral column. It arises with the stratum just described from the back of the body of the pubis, and passes backwards on its perineal aspect. The fibres soon leave the rest of the muscle to pass around the lower part of the rectum, and meeting with the fibres from the opposite side, form a strong loop or girdle which slings the rectum up to the symphysis pubis Further, as its name indicates, it is a powerful sphincter of the rectum.

(*c*) The **levator prostatæ** is the name given to the bundle of fibres which, leaving the pubo-coccygeus soon after its origin, passes backwards and downwards on the side of the prostate and in some cases on the side of the urethra, immediately after it emerges from the prostate. The fibres are inserted into the central point of the perineum, and as they are the only fibres of the

FIG. 895.—LATERAL VIEW OF MUSCLES OF THE FLOOR OF THE PELVIS. (W. A.)
(A portion of the ischial and pubic bones sawn away.)



levator ani which are inserted in front of the rectum, the name of *pre-anal fibres of the levator ani* is frequently applied to them.

Action of the Levator Ani.—Whilst the whole of the levator ani takes part in the formation of the pelvic diaphragm and thus contributes to the support of the abdominal viscera, the constituent elements of which it is composed have widely different functions.

From a consideration of the attachments and strength of the ilio- and pubo-coccygei, it is probable that the ilio-coccygeus, at least, acts almost exclusively as a supporting agent. The muscle flexes the coccygeal vertebræ on one another and the coccyx as a whole on the sacrum during the early period of life, but it has no direct action upon the rectum or any other of the pelvic viscera.

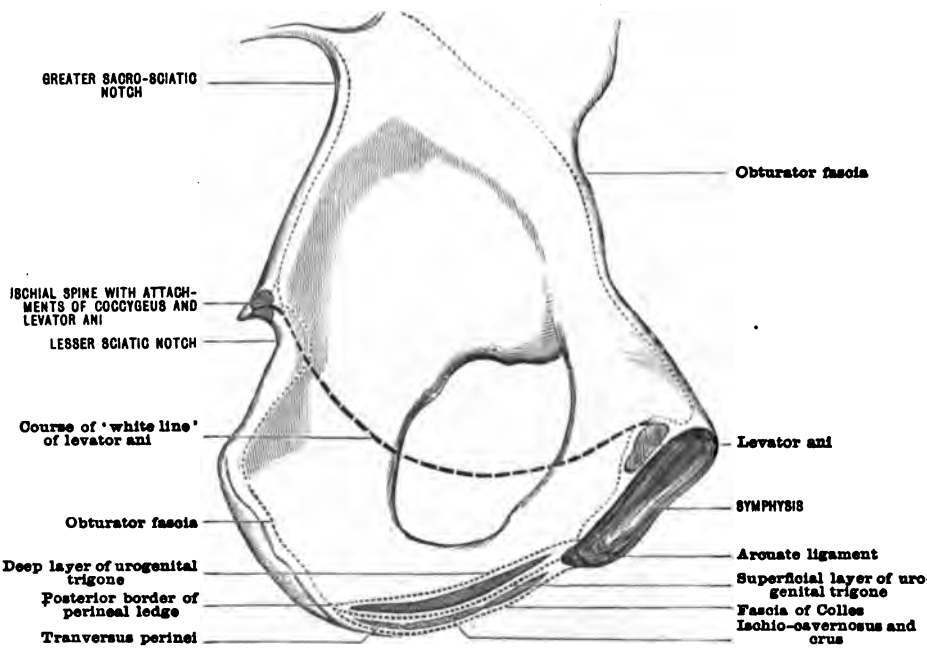
On the other hand, the pubo-coccygeus attains the highest functional importance, particularly in the female. Not only does it act on the rectum and support

the viscera in both sexes, but in the female it also influences the lumen of the vagina, and has an important bearing on the mechanism of parturition. It will be found convenient to consider each of its actions separately: (1) action on the rectum; (2) as a support to the viscera; (3) action on the vagina; (4) action during parturition.

(1) **Action on the Rectum.**—It may be said that the pubo-coccygeus is both a levator of the pelvic floor and a sphincter of the rectum, though the sphincteric action is the more important of the two.

Fig. 897 shows the two levatores ani forming a muscular diaphragm through which the rectum is transmitted, and by which it may be compressed on all sides. It is clear that the muscular fibres form almost a complete circle around the rectum, and that the part which is deficient is in front, where the pre-anal fibres terminate in the fibrous tissue constituting the central point of the perineum. Such an arrangement must lead to narrowing of the rectum when the muscle is thrown into action. Further, the pubo-rectalis forms a muscular loop which embraces the rectum and slings it up towards the pubes, and these fibres are capable of raising not only the rectum, but the pelvic floor as a whole.

FIG. 896.—DIAGRAM SHOWING LINES OF ATTACHMENT OF THE FASCIÆ AND MUSCLES OF THE PELVIS. (W. A.)



Briefly, therefore, the action of the pubo-coccygei on the rectum is to constrict the lower part of the bowel; at the same time it can elevate the anus upwards and forwards towards the symphysis pubis.

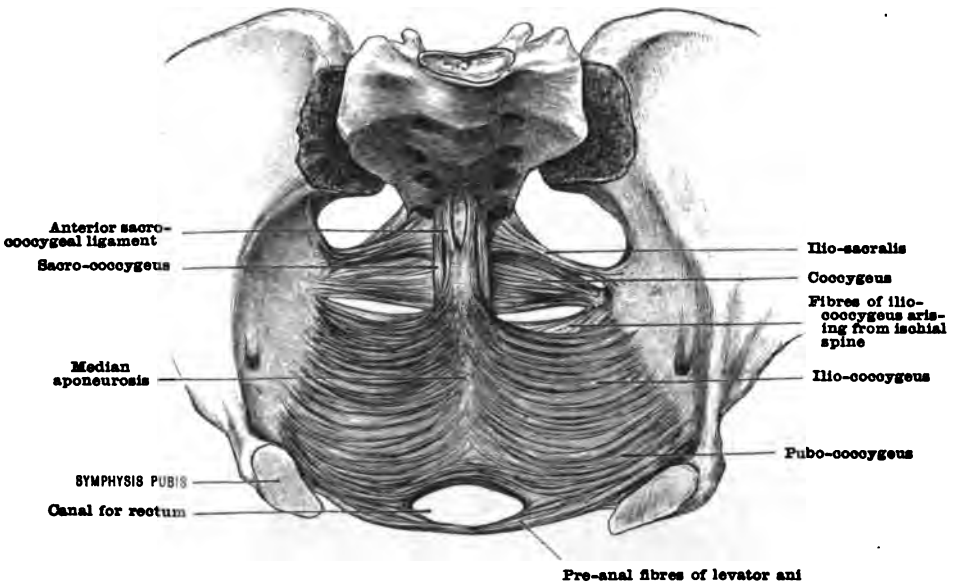
(2) **As a Support to Viscera.**—The pubo-coccygei are perhaps the most important muscles in the pelvic floor, since upon them depends the restoration of the floor to its normal position after it has been depressed by defæcation, etc. The two muscles form a well-marked curve with the concavity upwards and the convexity downwards, and attached at each end to the bones of the pelvic outlet. The anterior end is attached to the pubes, the posterior end to the coccyx, whilst between these two points, the central parts are free from bony attachments. When the pelvic floor is depressed its concavity is increased; it is raised when the pubo-coccygei contract from the two fixed points, and the concavity is diminished. This arrangement of the pubo-coccygei is admirably adapted for the support of superimposed structures.

(For the action of the levator ani on the vagina and during parturition, see page 1227.)

The levator ani receives its nerve-supply either from the third or fourth sacral nerve and sometimes from both. The nerve fibres enter the muscle on its pelvic surface.

The **coccygeus** is a thin and rather unimportant plane of muscular fibres, supported by and blending intimately with the sacro-spinous (small sacro-sciatic) ligament. It arises from the inner surface of the ischial spine above the levator ani, and passes backwards and inwards, expanding to become inserted into the sides of the second and first pieces of the coccyx, the lateral sacro-coccygeal ligament, and the last two pieces of the sacrum. Its visceral surface looks almost directly forwards and is covered by a continuation of the endopelvic fascia. Its parietal

FIG. 897.—THE PELVIC DIAPHRAGM SEEN FROM ABOVE, AFTER REMOVAL OF THE RECTUM AND SEPARATION OF THE PUBIC BONES.



surface is in contact with the sacro-spinous ligament. Its superior border is separated from the inferior border of the piriformis by the vessels and nerves which escape from the pelvis below the latter muscle. Its inferior border is related to the posterior border of the ilio-coccygeus and sometimes an accessory muscle, the ilio-sacralis, a dorsal extension of the ilio-coccygeus, actually lies in front of it (Fig. 897). The muscle is often pierced by filaments of the fourth and fifth sacral and coccygeal nerves, which supply it and form a kind of plexus on its pelvic surface. The coccygeus in man no longer acts as an *abductor caudæ*, as it does in lower animals, but simply assists in closing the outlet of the pelvis and aids the levator ani in drawing forwards the coccyx.

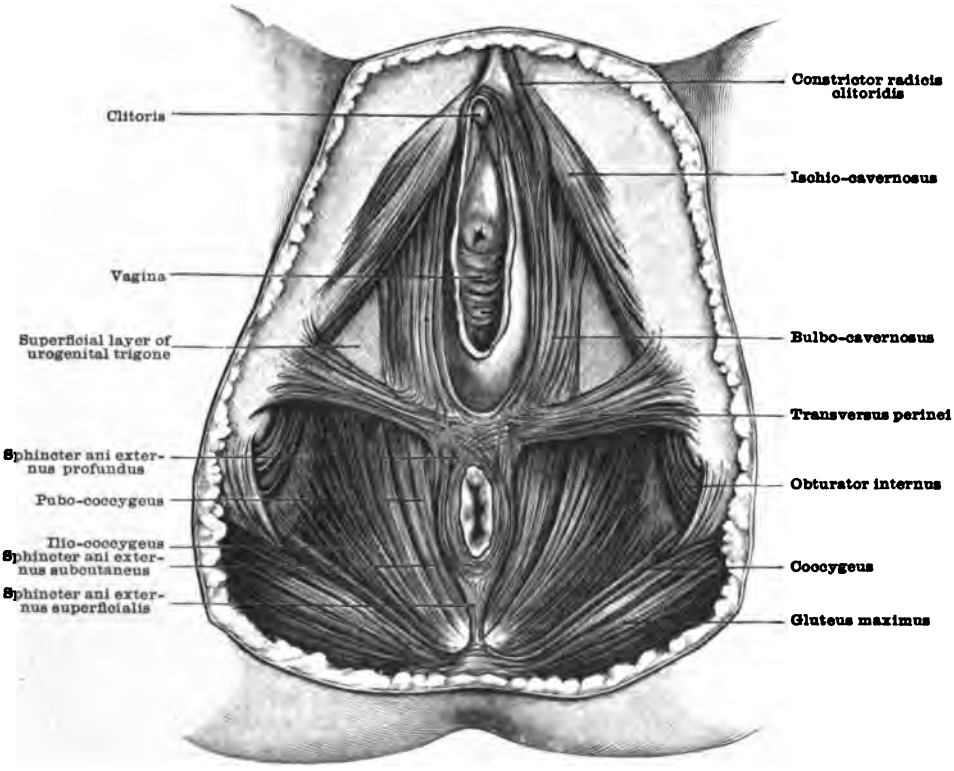
THE PELVIC FLOOR IN THE FEMALE

The pelvic floor of the female differs from that of the male partly in the perforation of the whole of its fascial and muscular structures in the middle line by the vulvo-vaginal passage, and partly in the adaptation of the perineal muscles to the modified conditions of the external genital apparatus. The corpora cavernosa penis are represented by the relatively diminutive **corpora clitoridis;** the ischio-cavernosi are proportionately reduced in size, but differ in no other material respect; the corpus spongiosum is divided into two lateral segments, which are represented by the **bulbi vestibuli** and **partes intermediales;** and the two bulbo-cavernosi are separate, and appear in an attenuated form, spread over the erectile tissue as a plane of fibres, the **sphincter vaginæ,** which is sometimes difficult to recognise on dissection; while the median raphe uniting the two muscles in the male gives place to the **genital fissure.** The **superficial transversi perinei**

differ only in size from those of the male; but the **sphincter urethræ membranaceæ** is of course cleft by the vagina, and its fibres are relatively thin and weak and in great part unstriped. The **greater vestibular glands (glands of Bartholin),** although morphologically identical with the bulbo-urethral glands, are less deeply placed.

The greater development of the connective-tissue structures between the genital canal and the third stage of the rectum, leading to the formation of the **perineal body,** is also a peculiarity of the female. The perineal body is triangular in sagittal section, and bounded in front by the vulvo-vaginal wall, behind by the anterior wall of the rectum, and below by the integument between the posterior vulvar commissure and the anal aperture. It consists of a strong meshwork of connective tissue, freely intermingled with fibres of elastic tissue and unstriped muscle, and is traversed by the various muscles which meet at the tendinous centre of the perineum. It becomes stretched to a remarkable degree during the pas-

FIG. 898.—THE PERINEAL MUSCLES IN THE FEMALE.



sage of the child's head in labour, but is saved from rupture by its strength and elasticity.

As the bulbo-cavernosus and sphincter urethræ membranaceæ muscles are considerably modified in the female, special reference must now be made to them.

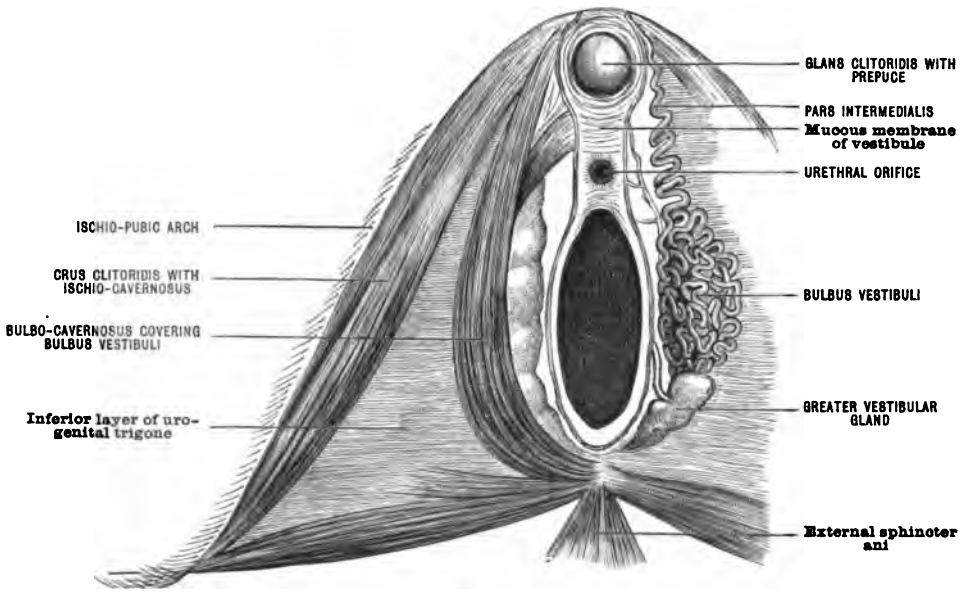
The **bulbo-cavernosus** in the female is a composite structure like the corresponding muscle in the male. It extends from the perineal septum behind to the clitoris and symphysis pubis in front, and is situated on the outer aspect of the bulb of the vestibule and the greater vestibular gland. Below and internal to the bulb a few fibres are in relation to the lower end of the vagina and urethra. The whole group of fibres is usually referred to as the **sphincter vaginæ,** though it should be pointed out that the muscle bearing this name is not the only one which can influence the size of the vaginal canal. It arises at its lower and posterior end from the central point of the perineum, where it also receives fibres from the external sphincter ani and the transversus perinei. The muscle is then directed forwards and outwards on each side around the posterior commissure, and after

proceeding for a short distance it is occasionally joined by a narrow bundle of fibres which take origin from the fibrous septa in the ischio-rectal fossa. Thus constituted, it forms a muscular band about 18 mm. ($\frac{3}{4}$ in.) wide encircling the vaginal orifice and covering the bulbs of the vestibule and the greater vestibular glands.

Anteriorly the muscular fibres terminate in three ways. The external set are attached to the inner margin of the pubic and sometimes the ischial ramus, blending with the adjacent urogenital trigone and the tunica fibrosa of the corpus cavernosum of the clitoris. The middle set form a distinct bundle which crosses the crus of the clitoris superficially to terminate in the neighbourhood of the suspensory ligament of that organ, in the substance of the mons pubis. Finally the internal pass into the preputium clitoridis, the anterior vaginal wall, and the tissue between it and the lower end of the urethra.

Proceeding now to compare the bulbo-cavernosi in the two sexes, it may be stated that although the two muscles do not apparently resemble each other, it is not difficult to establish the homology between them. The only division which has not been recognised in the female is that corresponding to the *compressor hemisphærium bulbi* in the male. On the other hand, each of the three remaining parts

FIG. 899.—DIAGRAMMATIC REPRESENTATION OF THE PERINEAL STRUCTURES IN THE FEMALE.



of the male bulbo-cavernosus is represented in the female. Thus, the most superficial layer—the *ischio-bulbosus*—may be present as a layer of muscle arising from the ascending ramus of the ischium and terminating in the muscle which covers the bulb, though this layer is not present so frequently as in the male.

The *compressor bulbi proprius* and the *constrictor radicis clitoridis* constitute the group of fibres enveloping the bulbs of the vestibule and the glands of Bartholin. As they correspond to the main parts of the bulbo-cavernosus in the male, it is convenient to use the same nomenclature in the two sexes. The three parts of the bulbo-cavernosus in the female may be enumerated thus: (1) The ischio-bulbosus; (2) the constrictor radicis clitoridis; and (3) the compressor bulbi proprius.

(1) The **ischio-bulbosus** is very similar to the corresponding muscle in the male, and little need be added to the description previously given. (2) **Constrictor radicis clitoridis.** Under this name are included those fibres which, arising from the central point of the perineum, pass forwards to terminate in the subcutaneous tissue of the mons pubis, and if any evidence were necessary to complete the homology of the bulbo-cavernosi muscles in the two sexes, these remarkable strands of muscular fibres would supply it. (See constrictor radicis penis, page 1214.) The most internal fibres of the bulbo-cavernosus which pass into the preputium clitoridis and anterior vaginal wall may also be included in the constrictor radicis. (3) **Compressor bulbi proprius.** The fibres of this division are situated immediately external to those of the constrictor radicis clitoridis. They take origin from the central point of the perineum, and after forming

a covering for the bulb of the vestibule, obtain insertion into the margin of the pubic arch, the tunica fibrosa of the corpus cavernosum, and the urogenital trigone.

Action and Nerve-supply.—The muscles serve to compress the vestibular bulbs, and, acting in association with the pubo-coccygeal portions of the levator ani, narrow the vaginal orifice. Their nerve-supply is derived from the internal pudic.

The **sphincter urethræ membranaceæ** when well developed consists of two distinct groups of fibres like the sphincter of the membranous urethra in the male. One group surrounds the urethra in the form of a muscular sheath, the other extends transversely or obliquely across the pubic arch, and this part of the muscle is almost completely divided into lateral halves by the vagina.

The fibres constituting the muscular sheath for the urethra are to be regarded as the true sphincter urethræ. They arise from the walls of the veins which form the plexus on the anterior wall of the vagina and urethra, and from the tough fibrous tissue lying on the urethra between the back of the symphysis pubis and the neck of the bladder. Surrounding the urethra either circularly or obliquely, most of the fibres terminate in the tissue between the urethra and the anterior vaginal wall. Whilst this is the usual arrangement of the true sphincter of the membranous urethra, a bundle of fibres may frequently be observed directed sagittally on either side of the urethra, which obtains attachment to the lowest part of the back of the symphysis pubis.

The transverse fibres of the sphincter urethræ are situated between the two layers of the urogenital trigone. They take origin from the descending ramus of the pubis, from the transverse ligament of the pelvis, and from the walls of the neighbouring veins. Their insertion varies at the upper and lower parts of the layer. The superior fibres are directed inwards, and in front of the urethra join with the corresponding fibres from the opposite side. The succeeding fibres pass to the tissue between the urethra and the anterior vaginal wall, where they meet and join with fibres from the transversus perinei profundus. The lowest fibres are directed obliquely inwards and downwards and blend with the vaginal wall.

The sphincter urethræ membranaceæ in the female is usually more difficult to demonstrate than the corresponding muscle in the male. This is largely due to the number of smooth muscular fibres which enter into its substance, and to the prominent venous plexus which lies on the anterior wall of the vagina and urethra.

The arrangement of the **transversus perinei profundus** is somewhat similar to that in the male, though, owing to the presence of the vagina, the mode of insertion is slightly altered. As the muscle approaches the middle line it spreads out, and a few of the most anterior fibres pass to the anterior wall of the vagina and lie behind the urethra. These fibres have been named by Führer the 'transversus vaginæ.' The remaining fibres pass behind the vagina to the central point of the perineum. On account of the course which the fibres of the transversus perinei profundus take around the vaginal wall, Führer refers to the whole muscle as the 'levator vaginæ.' In the female the muscle is more frequently absent than in the male.

The Pelvic Diaphragm in the Female

The pelvic diaphragm in the female differs from that of the male partly in its perforation by the vagina and partly in the adaptation of the pubo-coccygeus portion of the levator ani to greater functional activity. Little difference can be observed between the ilio-coccygeus in the two sexes, and it is difficult to say in which sex degeneration of the muscle is carried to the furthest point. The ilio-coccygeus is usually thinner and more membranous in the female, though this may be due to stretching of the muscle during parturition. Luschka, from a consideration of the size of the pelvis in the two sexes, points out that the levator ani as a whole is smaller, especially in its vertical measurement, in woman than in man, just as the height of the pelvis is less in the former. With these exceptions, the ilio-coccygeus in the female corresponds in situation, form, and attachments to the homologous structure in the male, and in both it is distinctly a degenerated muscle.

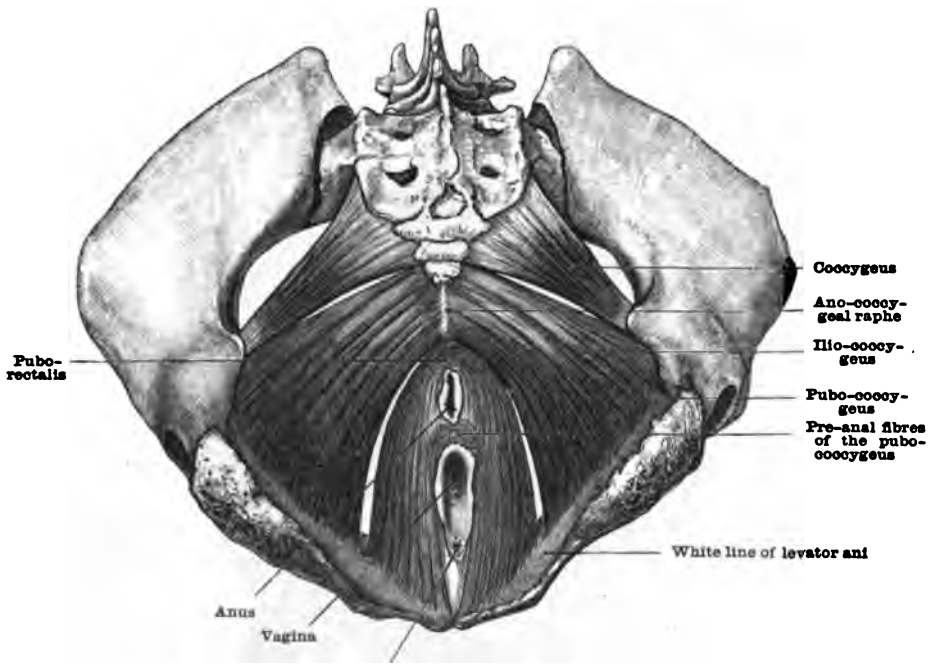
The pubo-coccygeus, on the other hand, is more strongly developed in the female, and this is probably due to increased functional activity. Not only does it act on the rectum and support the viscera, but it can also influence the lumen of the vagina and has an important bearing on the mechanism of parturition. In some subjects the pubo-coccygeus is greatly hypertrophied and forms a prominent muscular ring encircling the rectum and vagina, the thickening being more marked near

its origin from the pubis and where it lies in contact with the lateral vaginal wall. The level where the muscle lies in relation with the vagina corresponds to a point 0·6 to 1·2 cm. (¼ to ½ in.) above the level of the hymen.

Action of the pubo-coccygeus in the female.—*Action on the vagina:* In describing the action of the sphincter vaginæ it was stated that the closure of the vaginal canal was the result of the contraction of two associated muscles—the pubo-coccygei and sphincter vaginæ.

The pubo-coccygei pass backwards from the pubes on either side of the vagina, and in consequence are capable of exerting a marked lateral compression upon it. A more pronounced action is observed when the pubo-coccygei are associated in action with the sphincter vaginæ. The former compress the canal from side to

FIG. 900.—THE PELVIC DIAPHRAGM IN THE FEMALE, FROM BELOW AND BEHIND.



side, the latter from front to back by raising the vagina up towards the symphysis pubis, and in this way the narrowing of the passage is brought about.

Action during parturition: During normal parturition the action of the pubo-coccygei is chiefly exerted in pulling the perineum upwards after it has been depressed by the advancing head of the child. But cases constantly occur in which the muscle appears to obstruct the act of labour rather than to assist it; the obstruction may be but slight and easily overcome, or it may be more pronounced. Its extent depends upon the amount of contraction and consequent shortening of the pubo-coccygei.

(For the action of the muscle on the rectum and for the description of its arrangement to form a support to the viscera, see the account in the male.)

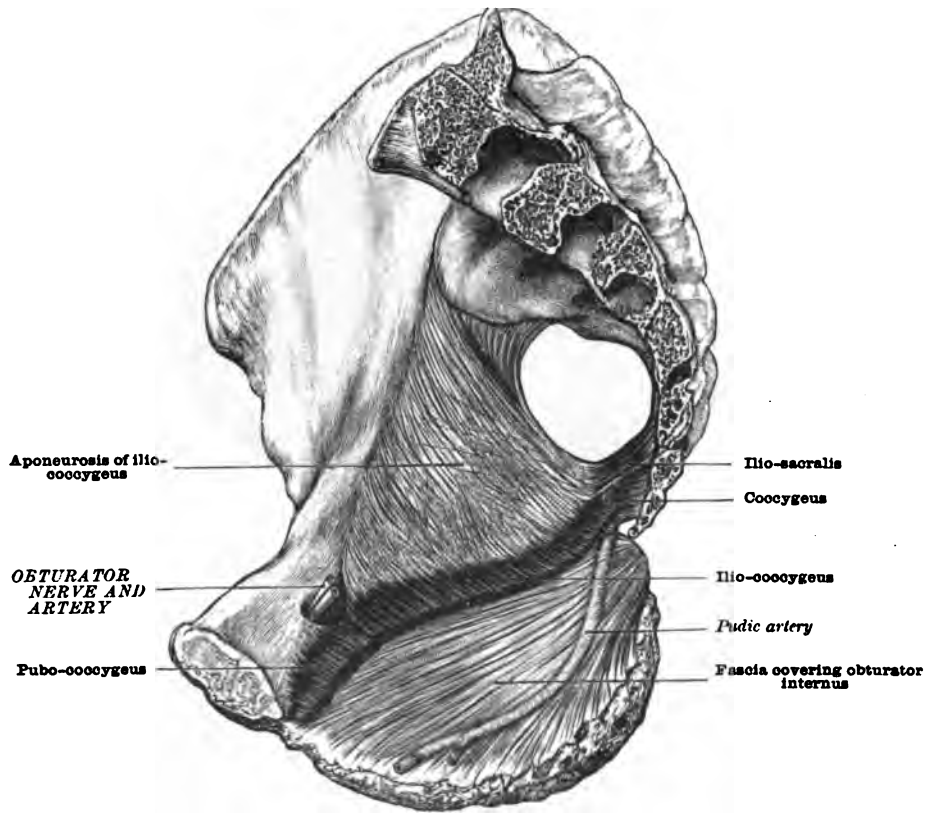
THE PELVIC FASCIÆ

The osseo-ligamentous framework of the walls of the true pelvis is constituted by the two ossa innominata below the terminal line and posterior border of the pubic crest, by the sacrum and coccyx, and by the sacro-tuberous (sacro-sciatic), sacro-iliac, and interpubic ligaments, and the obturator membrane. Supplementing these structures on each side of the median line, are four muscles: the obturator internus, the piriformis, the coccygeus, and the levator ani, together with their fascial investments.

The pelvic fasciæ may be conveniently considered in two sets: (1) all the fasciæ which form coverings or investments for muscles; and (2) the fascial layers which, in part, cover and support the viscera. The former of these sets may be termed the **muscular** set, and are named in accordance with their muscular relationships, as, for example, obturator fascia, piriformis fascia, and anal fascia. The second or **visceral** set comprises all the fascial layers which support and fix the pelvic viscera, and is designated the endopelvic fascia or fasciæ, though other terms are frequently used, such as the recto-vesical fascia and pubo-sacral fascia (Holl).

I. **The muscular fasciæ.**—Both the upper and lower surfaces of the levator ani in man are covered by thin layers of fibrous tissue closely adherent to the subjacent muscle. Posteriorly, the upper layers of the two sides are continuous behind the rectum, and fuse with the anterior sacro-coccygeal ligaments (tendinous insertion of the pubo-coccygei), and with the fascia investing the coccygeus. In the

FIG. 901.—THE RIGHT LATERAL PELVIC WALL, SEEN FROM WITHIN.



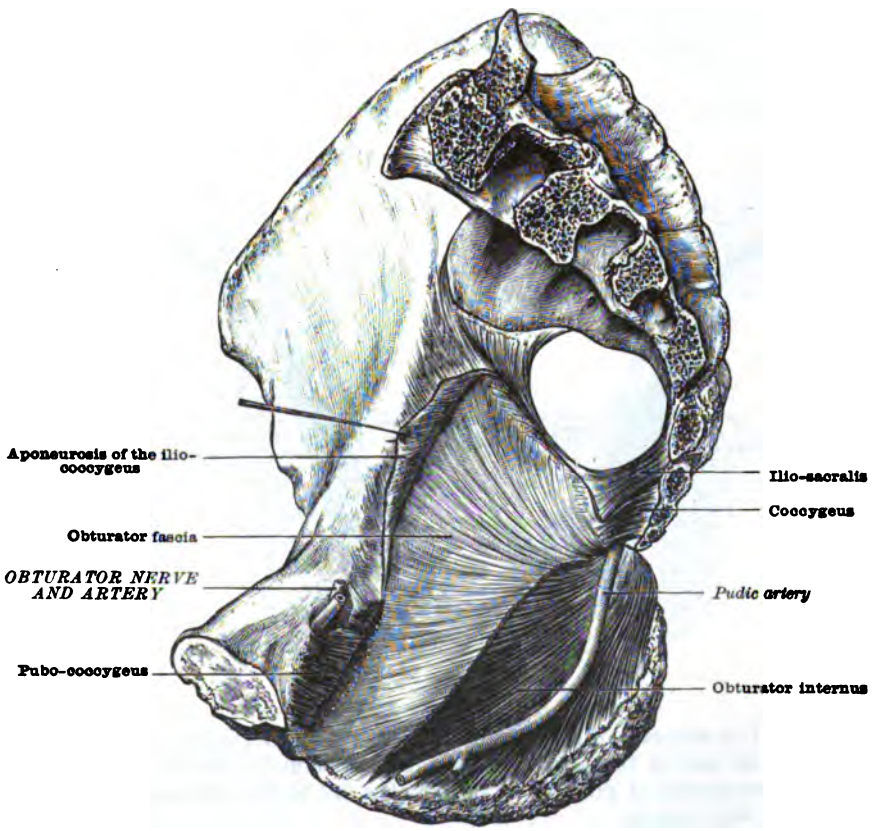
region of the canal through which the rectum passes, they descend in contact with the rectal wall, and end over the external sphincter ani, whilst at the front part of the pelvic floor the fascial layer of each side turns round the free inner edge of the pubo-coccygeus and becomes continuous with the layer on its under surface.

The lower fascia of the levator ani also presents a different disposition behind and in front. Posteriorly, where it covers the ilio-coccygeus, it forms a thin membranous layer—the anal fascia—which joins with the corresponding fascia of the opposite side in the ano-coccygeal raphe. In the region of the canal for the rectum it ends like the upper layer, over the external sphincter, and is finally lost in the subcutaneous fatty tissue in the region of the anus. In front of (or to the inner side of) the pre-anal fibres of the pubo-coccygeus, however, the fascia is continuous round the inner margin of the pubo-coccygeus with the upper fascia of the muscle, and externally passes to be attached to the descending ramus of the pubis and the ascending ramus of the ischium. Between its external bony attachment and the

inner border of the pubo-coccygeus, it lies in relation to the posterior surface of the sphincter of the membranous urethra and the transversus perinei profundus, thus forming with the obturator fascia the superior layer of the urogenital trigone. These two fasciæ on the upper and lower surfaces of the levator ani may be termed the **fascia supradiaphragmatica** and the **fascia infradiaphragmatica** respectively. And in order to understand their attachments to the lateral pelvic wall it is necessary that the obturator fascia should now be examined.

The **obturator fascia** is regarded as the special fascia of the obturator internus; it covers the inner surface of the muscle, and at its limits obtains attachment to the bone. Above, it extends to the iliac portion of the terminal line; in front, it is attached to the back of the body of the pubis; behind, it reaches beyond the muscle to the sacro-tuberous ligament; and below, it joins the falciform process

FIG. 902.—THE RIGHT LATERAL PELVIC WALL FROM WITHIN, SHOWING THE APONEUROTIC ORIGIN OF THE ILIO-COCCYGEUS SEPARATED FROM THE UNDERLYING OBTURATOR FASCIA.



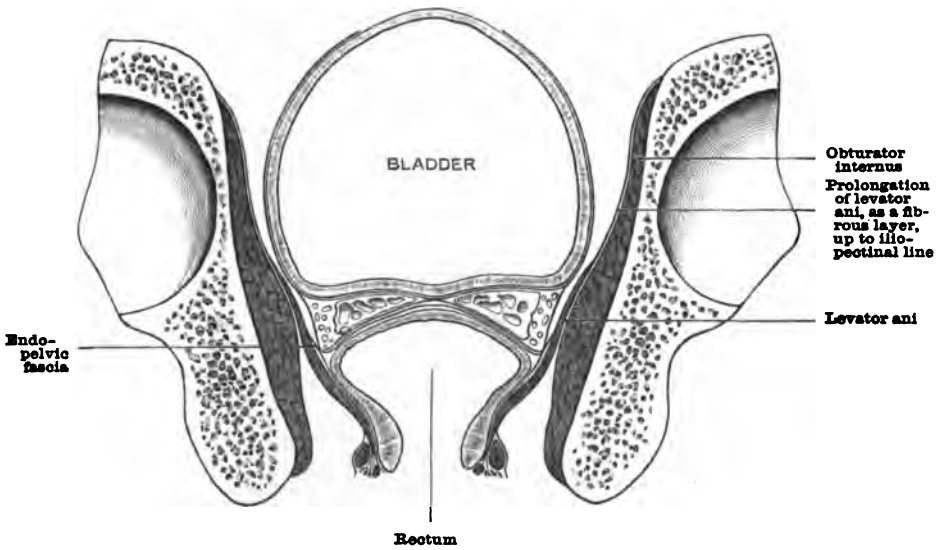
of the latter, and thus gains attachment to the ascending ramus of the ischium and the descending ramus of the pubis. At the small sacro-sciatic foramen it passes out of the pelvis with the obturator internus muscle, and appears in the post-femoral region of the thigh. At its borders it is closely related to, and indeed continuous with, the fascia iliaca above, the fascia piriformis behind, and the superior layer of the urogenital trigone below and in front.

By the attachment of the levator ani, the obturator fascia on the lateral pelvic wall is divisible into two parts, an upper **pelvic portion** lined by peritoneum, and a lower **ischio-rectal** portion forming the outer boundary of the ischio-rectal fossa. The two parts have a different appearance, and are not of equal thickness. The pelvic portion is thicker, more aponeurotic, and less transparent than the ischio-rectal portion, which is thinner and more membranous, allowing the underlying muscular fibres to be seen through it.

The pelvic portion, somewhat triangular in shape, ascends as high as the terminal line and descends as far as the origin of the ilio-coccygeal portion of the levator ani. In reality it consists of two layers fused together, one, next the obturator muscle, the proper obturator fascia, and another, lying on the internal aspect of the obturator fascia, which represents the degenerate ilio-coccygeus. For in tailed animals the muscle corresponding to the ilio-coccygeus takes origin from the terminal line, whilst in man it arises from the fascia obturatoria along a line known as the **arcus tendineus musculi levatoris ani,** to distinguish it from the white line of the pelvic fascia. Clearly, therefore, the origin of the ilio-coccygeal portion of the levator ani from the obturator fascia is a *secondary* attachment, and by careful dissection it can be demonstrated that the part between this and the *primary* origin from the terminal line has been converted into a thin aponeurosis which tends to fuse with the underlying fascia obturatoria.

The level of the arcus tendineus is very variable and obviously depends on the extent to which degeneration of the ilio-coccygeus proceeds. Indeed, the arcus tendineus may assume any position between the pelvic brim and a horizontal line drawn through the ischial spine to the back of the body of the pubis. The attachment may in some cases reach within a quarter of an inch of the terminal (ilio-pec-

FIG. 903.—DIAGRAM TO SHOW THE FASCIÆ OF THE PELVIS IN SECTION. (After Holl.)



tineal) line, and in others it may descend so low as to practically coincide with the level of the 'white line' of the pelvic fascia. The attachment of the upper and lower fasciæ of the ilio-coccygeal portion of the levator ani to the obturator fascia is the same as that of the muscle.

II. **The Endopelvic Fascia (Recto-vesical Fascia).**—This is a well-marked fascial structure, extending on each side of the pelvic viscera, from the front to the back of the pelvic cavity. Externally, it is directly attached to the upper fascia of the levator ani, along a line which extends from the pubo-prostatic ligament to the spine of the ischium. At this level there is usually a more or less definite streak, the **arcus tendineus** ('white line') of the pelvic fascia, which simply indicates the line of fusion of the two fasciæ. From its external or lateral attachment, the fascia is directed downwards and inwards, in contact for a variable distance with the upper fascia of the levator ani, to the side of the prostate, to the base of the bladder, and to the side of the rectum, and then divides into two layers, ascending and descending, which serve to partly cover the viscera and to attach them to the lateral pelvic wall.

The ascending layer is reflected upwards over the bladder, and soon becomes closely united with its muscular coat; behind and above the prostate it gains attachment to the base of the bladder, immediately outside the line of the vesiculæ semi-

nales. At the side of the rectum it is connected with the sheaths of the hypogastric vessels, and is lost in the loose areolar tissue of this region.

The descending layer envelopes the prostate and constitutes its sheath. The layer descends on the lateral and posterior aspects of the organ as far as the apex, where it joins with the muscular fasciæ of the levator ani and is continued around the inner margin of the pubo-coccygeus into the superior layer of the urogenital trigone. In front the sheath receives the backwardly directed pubo-prostatic ligaments, which are attached in front to the posterior surface of the pubes, and behind to the anterior aspect of the prostate.

In the posterior part of the pelvic cavity the layer descends along the lateral wall of the rectum, behind which it joins with the corresponding layer of the opposite side, and is finally lost over the sphincter muscles at the lower end of the bowel. Between the bladder and rectum the descending layers of the two sides are joined together, and in this way the front part of the rectal sheath is completed. The intervening layer, in addition, gives a covering to the vesiculæ seminales in the male, and to the vagina in the female. The white line of the pelvic fascia is peculiar to man, and the absence of this thickening constitutes the most obvious difference in the general arrangement of the endopelvic fascia in man and other primates. But even in man, in whom the endopelvic fascia is specially developed, the 'white line' is not always recognisable. When present, as already pointed out, it may coincide with the arcus tendineus of the levator ani. On the other hand, it is more usual to find the tendinous thickening lying upon the inner (upper) surface of the muscle, immediately below its apparent origin from the side wall of the pelvis.

SECTION XI

THE DUCTLESS GLANDS

ORIGINALLY WRITTEN BY SIR FREDERICK TREVES, K.C.V.O., F.R.C.S.; ARTHUR HENSMAN, F.R.C.S., AND ARTHUR ROBINSON, M.D., M.R.C.S., REVISED BY

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THE SPLEEN

Position.—The **spleen** (**lien**) is situated for the most part in the left hypochondriac region (figs. 808, 907). It is deeply placed between the fundus of the stomach and the diaphragm, and extends forwards to reach the mid-line of the axilla between the eighth and eleventh ribs. It is covered by the ninth, tenth, and eleventh ribs (fig. 815), and is separated from them by the diaphragm, and to a smaller extent by the lung. Its upper end reaches to the level of the ninth thoracic spine, and its lower end to the level of the twelfth thoracic spine. Its inner extremity is within 5 cm. of the median plane of the body, and its outer boundary is posterior to the mid-axillary

FIG. 904.—OUTER ASPECT OF THE SPLEEN.

line. A line drawn from the left sterno-clavicular joint to the tip of the eleventh left rib bounds the anterior margin of the spleen.

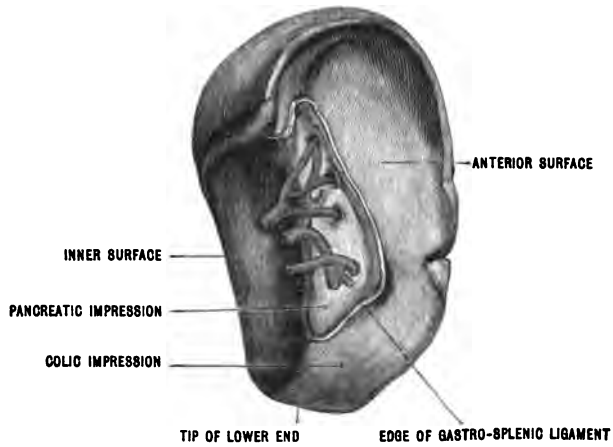
It is bluish-red in colour, is soft, and easily lacerated.

Its **shape** varies, and depends much upon the condition in which it is examined. If soft, and as usually found after removal from the body, it can only be said to have two surfaces, an outer convex and an inner concave; but if examined after it has been hardened *in situ*, after the manner of Professor His, it is seen to be of a much more precise shape, and to present three surfaces (figs. 904, 905).

Viewed from the outside, it presents a form which is irregularly oval, wider above than below, with a bulging of the anterior border (fig. 904). The three

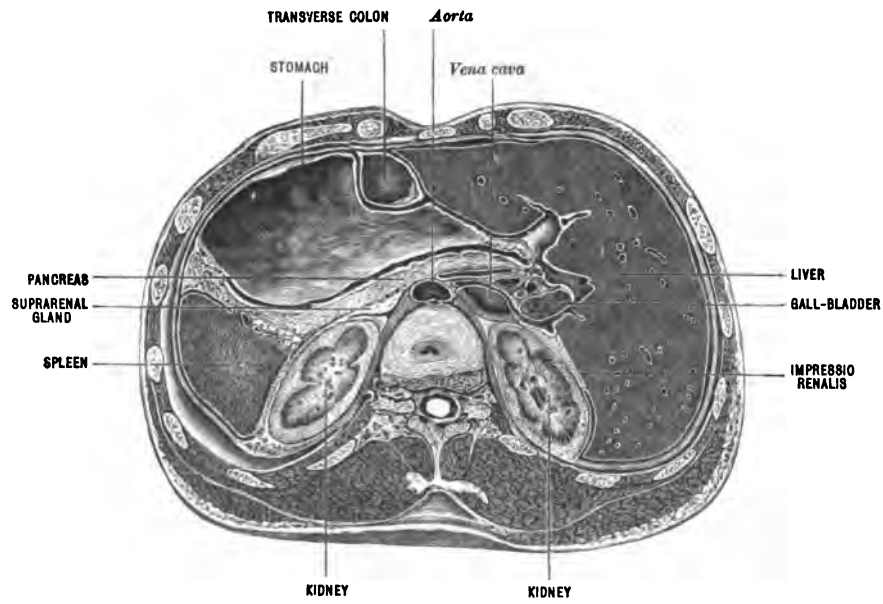
surfaces are the external, anterior, and inner. The **external, posterior,** or **diaphragmatic surface** is the largest. It is regularly convex, and is directed outwards and backwards and somewhat upwards (figs. 904, 906). It lies against the commencement of the arch of the diaphragm, and is covered by peritoneum. It is separated by the peritoneum and diaphragm, and to some part of its extent by the

FIG. 905.—INNER ASPECT OF THE SPLEEN.



pleura and lung from the eighth, ninth, tenth, and eleventh ribs. Viewed from the inside, the two other surfaces are seen to be divided by a distinct, vertically directed ridge (fig. 905). The **anterior** of the two, the **gastric surface,** looks forwards, inwards, and a little downwards. It is concave from above downwards and from side to side. It is a good deal the larger of the two, and is semilunar in shape (fig. 905).

FIG. 906.—TRANSVERSE SECTION OF THE BODY AT THE LOWER PART OF THE EPIGASTRIC REGION. (Rüdinger.)



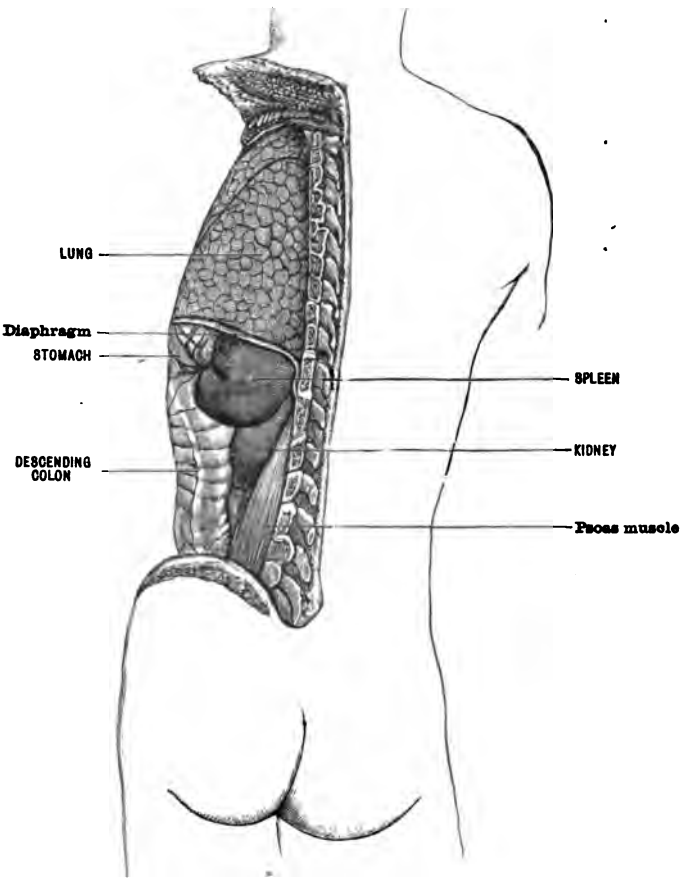
It is in contact with the fundus of the stomach, with the tip of the pancreas, and the extreme point of the left colic flexure (fig. 907). The colic impression is usually very distinct, and differs in direction from the gastric surface; it is now usually described as the *colic* or *basal surface.* Near the posterior border of the gastric surface and bounded by the ridge is seen the **hilus** of the spleen, a depression running vertically

from above downwards. It is here that the splenic artery and vein enter the gland, the vein being behind. In front of the hilus is seen the attachment of the gastro-splenic ligament; behind it is the attachment of the lieno-renal ligament, a fold of peritoneum which binds the spleen to the left kidney and through which the splenic vessels reach and leave the spleen. The ridge separating this surface from the inner surface is well defined, and runs from the top of the spleen to the lower part of the posterior border.

The **inner** or **renal surface** is much narrower and shorter than the anterior. It is only slightly concave in both directions. It is directed inwards and downwards and is in relation with the outer border of the left kidney.

The **anterior border** of the spleen is more defined than the posterior, is sharper, and is marked by several notches, one of which is occasionally larger than the others.

FIG. 907.—VIEW OF THE SPLEEN, ETC., FROM BEHIND. (Rüdinger.)



This border is convex. The **posterior border** is shorter and straighter. It separates the renal and diaphragmatic surfaces. The term **inner border** is applied to the ridge between the gastric and renal surfaces.

The spleen is set obliquely in the body. Its long axis about corresponds to the line of the tenth rib.

The size of the spleen varies with its blood content. In the adult it measures generally about 12 to 15 cm. in length, 7·5 to 10 cm. in breadth, and 2·5 to 4 cm. in thickness. Its average weight is 170 gm.

It is entirely surrounded by peritoneum except at the hilus. In front of the hilus the gastro-splenic ligament is attached. This reflexion of peritoneum, sometimes called the gastro-splenic omentum, passes inwards to the left extremity of the stomach and the left margin of the great omentum. A fold of peritoneum, the

phrenico-splenic ligament, connects the upper end of the spleen to the diaphragm. The reflexion of peritoneum from the spleen to the left kidney is called the lieno-renal ligament.

Variations.—The principal peculiarity is due to the presence of supplementary spleens (lienculi), found near the hilus in the gastro-splenic ligament, or less often in the great omentum. From one to twenty of these small bodies may be met with. They are red and round, of the same structure as the spleen, and vary in size from a pea to a walnut.

Structure.—The spleen is covered by peritoneum, beneath which is found a fibro-muscular capsule which sends numerous branching trabeculæ into the organ, forming a framework in which course the vessels, more especially the veins. The trabeculæ are in connection with a reticular network which permeates the spleen substance or spleen-pulp. Mall has shown that the trabeculæ and vascular system together outline masses of spleen-pulp about 1 mm. in diameter, known as **splenic lobules.** Each lobule is bounded by three main trabeculæ, from each of which three secondary trabeculæ pass into the substance of the lobule, partly dividing it into ten compartments, filled with splenic pulp, arranged in the form of columns or cords and designated as **pulp-cords.** The branches of the splenic artery, after coursing for a short distance in the main trabeculæ, leave these, and, after further division, become surrounded with a layer of adenoid tissue, which layer presents here and there irregular thickenings forming the Malpighian corpuscles. An arterial branch, surrounded with adenoid tissue, enters the apex of a spleen lobule, constituting its intralobular vessel, which, soon after entering the lobule, loses its adenoid sheath and then sends a branch to each of the ten above-mentioned compartments. These give off terminal branches which course in the pulp-cords, and terminate directly or indirectly in the venous spaces found between the pulp-cords. From the latter the blood passes, by means of small veins, to interlobular veins situated in the trabeculæ bounding the lobules.

Blood-supply.—The spleen receives its blood from the splenic artery, which is very large in proportion to the body it supplies. It divides before entering into about six branches. The artery is very tortuous. The vein, on the other hand, is straight, and lies below the artery.

The **lymphatics** are divided into a superficial and a deep set. The former form a plexus beneath the peritoneum. The latter are derived from fine perivascular spaces in the adenoid tissue around the vessels. They join at the hilum, and pass between the layers of the lieno-renal ligament to nodes behind and along the upper border of the pancreas.

The **nerves** are from the right vagus and the cœliac (solar) plexus. They pass in along the splenic artery.

Development of the spleen.—The spleen developes in connection with the meso-gastrium, probably in part from the mesothelial cells covering its left surface, also from the embryonic connective tissue found between the two mesothelial layers. Over the region of the meso-gastrium in which the spleen has its origin the mesothelium of the left layer is thickened and stratified, and not sharply differentiated from the underlying embryonic connective tissue, and cells from the mesothelium appear to wander into the underlying connective tissue, forming a thickened mass. As development proceeds this thickened mass becomes gradually separated from the mesothelium, this again presenting the usual appearance of mesothelium, while the thickened mass differentiates into the spleen. The early blood-vessels of the developing spleen, especially the veins, are probably sinusoidal in nature.

THE SUPRARENAL GLANDS

The **suprarenal glands** are two small, irregularly shaped organs resting each upon the upper extremity of the corresponding kidney and the adjoining parts of its inner and anterior surfaces, and bound to it by subperitoneal connective tissue. They lie against the lumbar portion of the diaphragm opposite the eleventh rib, or tenth intercostal space, and are separated from each other by a space of about 6·5 cm. The left is usually a little higher than the right, owing to the greater elevation of its kidney.

The organ varies widely in dimensions within physiological limits. Its average weight is about 4 gm., its height 3 cm., and its greatest breadth at the base 4·5 cm.

The *right* suprarenal gland is pyramidal in form, with the apex directed upwards and somewhat inwards. Its **anterior surface** is related above to a special impression upon the under and back part of the right lobe of the liver, between the layers of the coronary ligament; internally, to the inferior vena cava, which slightly overlaps it; and below it is covered with peritoneum continuous with that of the kidney, except at its internal inferior angle, where it is crossed by the duodenum. The impression for the vena cava presents a not well-marked fissure, the **hilus** of the gland, which gives exit to the suprarenal vein. The upper portion of the **posterior surface** of the right suprarenal gland is in relation with the lumbar portion of the diaphragm, while the lower portion of this surface, also known as the base of this gland, rests on the kidney.

The *left* suprarenal gland is a little larger than its fellow, somewhat crescentic in shape, and encroaches less upon the summit of the kidney than the right, and more upon the inner border, reaching even to the hilus. Its **anterior surface** is

covered **above** by the peritoneum of the epiploic bursa or lesser sac of the omentum, which separates it from the stomach; and below, near its internal inferior angle, it is crossed by the upper border of the pancreas and the splenic artery. This surface also presents a fissure known as the **hilus.** **Externally** it is in contact with the upper extremity of the spleen, which passes a little behind it, and its inner border is separated from the aorta by the fibres of the lumbar portion of the diaphragm. The **posterior surface** of the left suprarenal gland, like that of the right, is divided into an upper portion, which rests on the lumbar portion of the diaphragm, and a lower portion, which rests on the kidney.

Accessory suprarenal glands are often present in the neighbourhood of the principal organs, also along the course of the spermatic vessels and near the sexual glands, especially in the broad ligaments, in which region relatively large glands, having the structure of suprarenal glands, have been found (*accessory suprarenal glands of Marchand*).

Structure.—The suprarenal gland is surrounded by a fibro-muscular capsule. The gland substance may be divided into a cortical and a medullary portion. The cortical portion is subdivided into a glomerular, a fascicular, and a reticular zone, according to the peculiar grouping of the gland cells in these respective zones. In the glomerular zone the cells are of irregular columnar shape, and grouped in coiled columns. In the fascicular zone the cells, which are of polyhedral shape, are arranged in more or less regular columns, while in the reticular zone the cells form trabeculæ or groups. A reticular connective-tissue framework, continuous with the capsule, surrounds the cell masses and cell columns of the several zones. The cells of the medulla show an affinity to chromic acid,—chromaffin cells,—and are grouped in irregular masses separated by septa of the reticulum and venous spaces. The arteries to the gland form a plexus in the capsule from which cortical branches, which form capillaries, are distributed to the cortex, and

FIG. 908.—RIGHT SUPRARENAL GLAND AS SEEN FROM IN FRONT. FIG. 909.—LEFT SUPRARENAL GLAND AS SEEN FROM BEHIND. FIG. 910.—HORIZONTAL SECTION THROUGH THE LEFT SUPRARENAL GLAND. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)

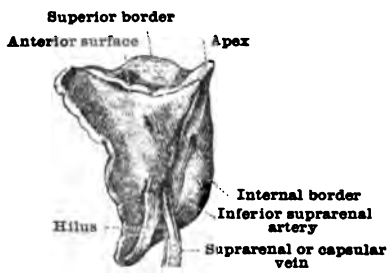


FIG. 908.

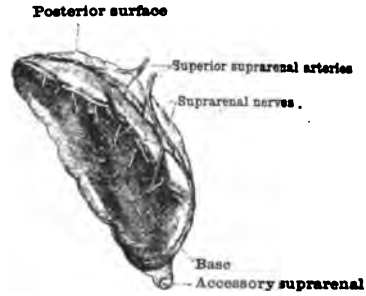


FIG. 909.

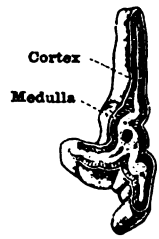


FIG. 910.

medullary branches, which pass through the cortex without branching, are distributed to the medulla, surrounding the cell-masses. The veins, which are relatively large and numerous in the medulla, leave the gland at the hilus. The secretion of the suprarenal gland—an internal secretion—passes into the veins.

Vessels and nerves.—The suprarenal glands are richly supplied both with vessels and nerves. The **arteries** are derived from three sources—the aorta, the phrenic, and the renal—and pierce the organ in various places, but chiefly on the anterior surface along a furrow called the hilus. The **veins** terminate on the right side in the vena cava, and sometimes by means of small branches in the phrenic and renal trunks; on the left, in the left renal vein. The **lymphatics** pass to the renal nodes. The **nerves** form a rich and complex interlacement, and are derived chiefly from the cœliac and renal plexuses, but include filaments from the splanchnics, and, according to some authors, from the phrenic and vagus also. Sympathetic ganglion-cells are found in the central portion of the glands.

Development.—The suprarenal glands of mammals appear to have their origin from two sources, although investigators who have given especial attention to their development are not agreed on this point. The cortical portion of the gland, which has its origin at a relatively early stage in development, appears to be derived from the mesothelium covering the anterior and mesial portion of the Wolffian ridges, either as a result of a proliferation of the mesothelial cells of this region or by invaginations of the same, forming a column or mass of cells surrounded by embryonic connective tissue. Some little time after the origin of the cortical portion of the gland, after this has to some extent undergone cellular differentiation and has become surrounded by a delicate capsule, there may be observed small, deeply staining cells, situated at the periphery of the cortical portion and beneath the capsule. From these cells, it would appear, is developed

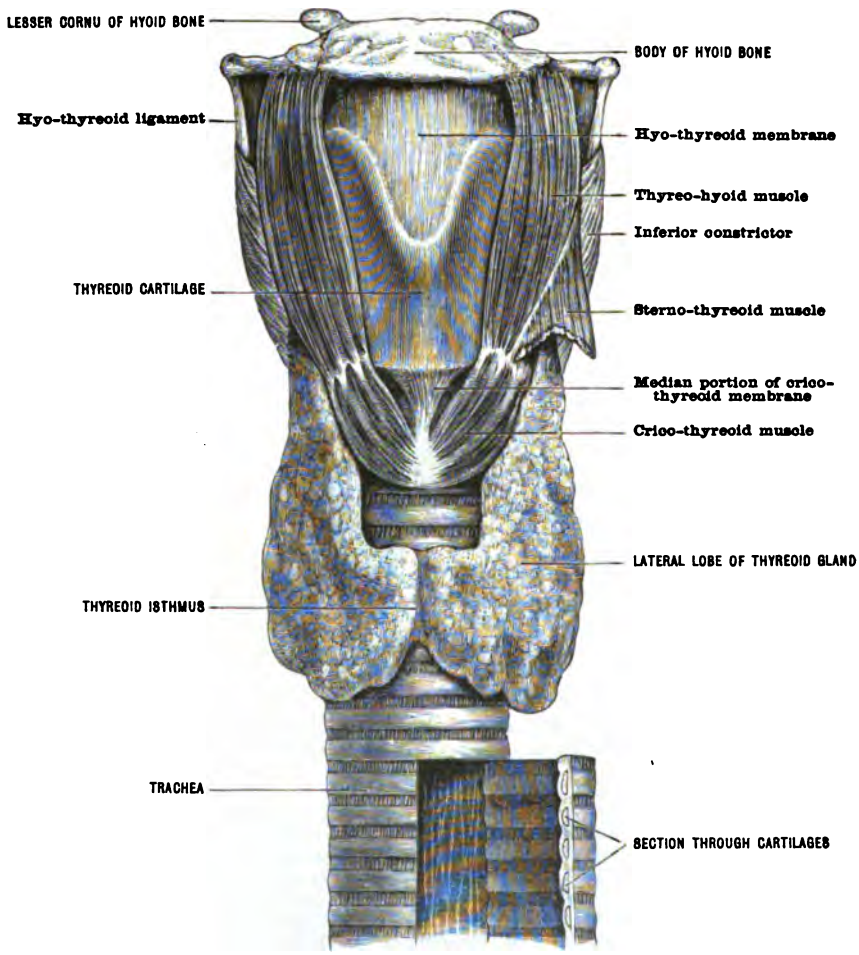
the medulla of the gland, they penetrating the cortical portion as development proceeds. The evidence at hand seems to indicate that the above-mentioned, small, deeply staining cells are derived from the neighbouring sympathetic ganglia. The suprarenal glands are relatively large in fœtal life, nearly attaining their full growth at birth; their relation to the kidneys is secondarily acquired.

THE THYREOID GLAND

The **thyreoid gland** is of a reddish colour, and is another of the ductless glands. It consists of two **lateral lobes** and a connecting **isthmus** which unites the lateral lobes nearer their lower than their upper ends. Its shape resembles somewhat that of a horseshoe.

The gland is convex and rounded on its outer surface, but its deeper surfaces are moulded to the parts which they overlie—the upper portion of the trachea and lateral surfaces of the larynx. It commonly weighs from 30 to 60 gm., but is larger in the female, and is often increased in size during menstruation.

FIG. 911.—VIEW OF THYREOID BODY.



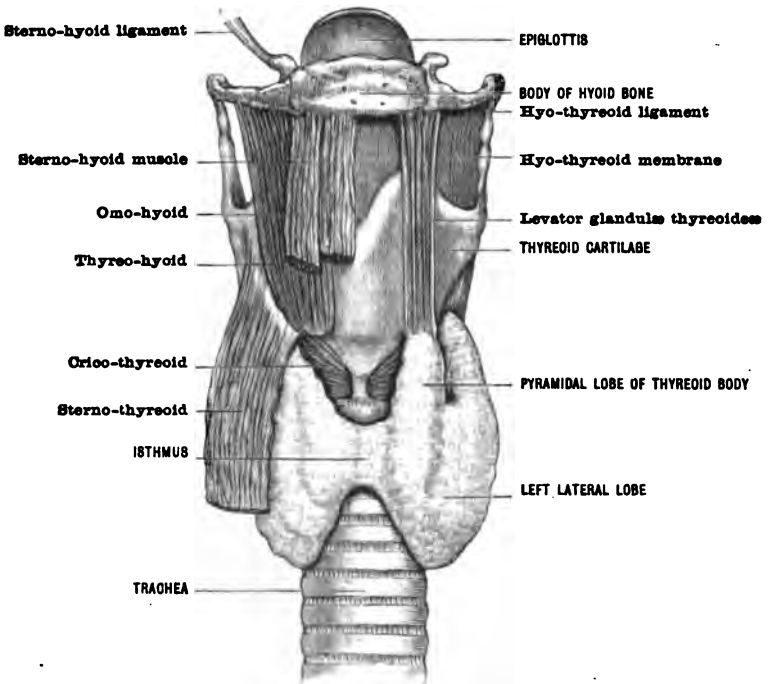
The lateral lobes are pyriform in shape, with their broad ends below, and measure about 5 cm. in length, 1·8 cm. in breadth, and about 2·5 cm. in thickness near the middle.

Relations of the lateral lobes.—The apex lies between the sterno-thyreoideus and the inferior constrictor of the pharynx, the latter separating it from the hinder part of the ala of the thyreoid cartilage and its inferior cornu. The base is rounded; it lies under cover of the sterno-thyreoideus and sterno-hyoideus, at the level of the sixth ring of the trachea and about 1·8 cm. above the sternum. Some of the larger

branches of the inferior thyreoid vein issue from it. The external surface is convex; it is covered by the sterno-hyoid, sterno-thyreoid, and omo-hyoid muscles, and it is overlapped by the anterior part of the sterno-mastoid. The internal surface is concave; it is moulded on the trachea. The posterior border is thick; it is in contact with the carotid sheath, and is grooved by the common carotid artery; on the left side it lies in front of the œsophagus, and on both sides, in front of the recurrent laryngeal nerve and the inferior thyreoid artery. The anterior border is thin; above, it is in relation with the internal terminal branch of the inferior thyreoid artery, and in the lower part of its extent it is united to the lobe on the opposite side by the isthmus.

Relations of the isthmus.—The isthmus varies in breadth from 6 to 18 mm. Its anterior surface is convex, and it lies in relation with the deep fascia, anterior jugular veins, superficial fascia, and skin. Its posterior concave surface rests upon the second, third, and fourth rings of the trachea. Its extremities are connected with the lower parts of the inner borders of the lateral lobes. Its lower border gives exit to some tributaries of the inferior thyreoid veins, and its upper border is in relation with the anastomosis between the internal terminal branches of the superior thyreoid

FIG. 912.—THYREOID GLAND, WITH PYRAMIDAL LOBE AND LEVATOR MUSCLE.



arteries; frequently a pyramidal lobe springs from it, and the levator glandulæ thyreoideæ, a narrow band of muscle, if present, arises from it and extends to the body of the hyoid bone. **The pyramidal lobe** is variable; when present, it is attached by its base to the upper border of the isthmus, usually to the left of the median line, or to the adjacent part of the left lateral lobe. Its length varies; it may extend upwards to the region of the hyoid bone. Masses of thyreoid tissue, of variable size, may be found in the region of the pyramidal lobe as far upwards as the hyoid bone, in relation with the lateral lobes, or on the trachea below the gland proper; these are known as **accessory thyreoids.**

The capsule and suspensory ligaments.—A fibrous capsule of deep cervical fascia completely encloses the thyreoid gland and sends septa inwards between its lobes. The superficial vessels ramify beneath it, and from its inner and back part two broad bands, the suspensory ligaments, pass upwards to the cricoid cartilage.

Structure.—The thyreoid gland is surrounded by a firm connective-tissue capsule, from which septa and trabeculæ pass into the gland, dividing it into lobules. The gland substance consists of variously shaped, non-communicating follicles, varying in size and separated by a

vascular connective tissue, continuous with the connective tissue surrounding the lobules and with that of the capsule. The follicles are lined with a single layer of epithelium, in which two varieties of cells are distinguished,—chief cells and colloid cells,—and are filled with colloid substance, the secretion of the gland. The secretion is conveyed from the gland by way of the lymphatics, the radicles of which are found in the connective tissue between the follicles. The vessels form a rich capillary network surrounding the follicles, and nerve-fibres have been traced to the epithelium of the follicles.

Vessels.—The **arteries**—which are relatively very large and frequently anastomose—are the two superior thyreoids, the two inferior thyreoids, and an occasional branch which ascends on the front of the trachea, the thyreoidea ima. This latter is derived either from the innominate artery or from the arch of the aorta.

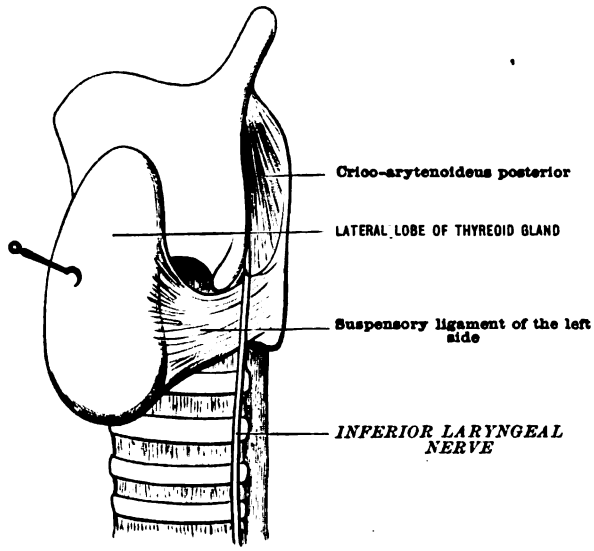
The superior thyreoid arteries descend to supply the apices and inner and fore parts of the lateral lobes; whilst the inferior ascend to supply their outer and hinder portions below.

The **veins** are the superior, middle, and the inferior thyreoid. The two former join the internal jugular vein, and the latter the innominate of the corresponding side, or they may unite to form a single vein which ends in the left innominate.

The **nerves** are derived from the inferior and middle cervical ganglia of the sympathetic.

Development.—The thyreoid gland has its development from three separate entodermal origins—a median unpaired bud and two lateral buds. The unpaired median bud may first be observed when the human embryo has a length of 3 mm., at the apex of the groove which separates the anterior from the posterior portions of the tongue. This bud obtains a lumen (*thyreo-glossal duct*) when the embryo attains a length of 4 mm., and its end becomes bilobed and its lumen lost when the embryo grows to 6 mm. Soon after this its connection with the bucco-pharyngeal epithelium is lost, its place of origin being, however, permanently marked by the foramen

FIG. 913.—THE SUSPENSORY LIGAMENTS OF THE THYREOID GLAND. (After Berry.)



cæcum. When the embryo has attained a length of 14 mm., its enlarged distal end becomes broken up into anastomosing trabeculæ. The two lateral buds arise from the entodermal portion of the fourth branchial cleft. They become separated from their place of origin and fused with the median portion when the embryo has attained a length of about 18 mm. The pyramidal lobe becomes evident when the embryo has grown to 26 mm. (Tourneux and Verdun.) Attention should be called, however, to the fact that there is not as yet a unanimity of views as to the extent to which the lateral thyreoid buds participate in the formation of the thyreoid. They very probably form only a relatively small portion of the entire thyreoid. The anastomosing epithelial trabeculæ become further broken up by an ingrowth of connective tissue as development proceeds, separated nests of cells developing into the follicles of the gland. The thyreo-glossal duct now and then persists either as a cord of cells or as a tube.

The para-thyreoid glands.—These are small glandular structures found in relation with the posterior surfaces of the lateral lobes of the thyreoid gland. They are surrounded by a thin connective-tissue capsule which sends septa into the gland substance, outlining imperfectly developed lobules. The glandular portion consists of trabeculæ of cells separated by blood-spaces—sinusoids. They resemble in structure embryonic thyreoid tissue, also, somewhat, the tissue of the anterior lobe of the hypophysis cerebri. Two such glandular structures are generally found on each side. One pair is situated at the level of the cricoid cartilage, in close relation with the posterior surface of the lateral lobe. The other pair, less constant in posi-

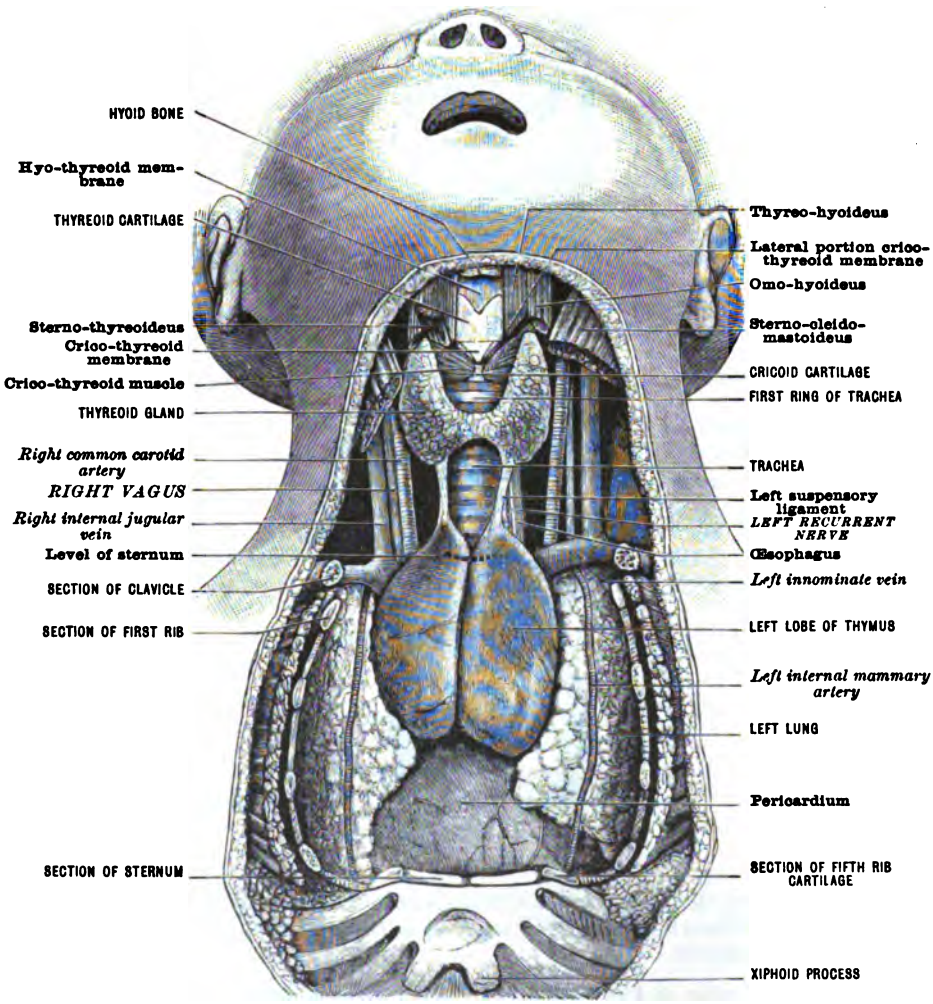
tion, may be found in relation with the lower portion of the lateral lobes of the thyreoid, or further down in the neck, in relation with the trachea. They arise in their development from the anterior surfaces of the entodermal portion of the third and fourth branchial clefts.

THE THYMUS GLAND

The **thymus gland,** like the thyreoid, is ductless, and may be classed with the lymphoid tissues. It is well developed in late fœtal life and in the new-born, and reaches its highest development about the end of the second year, although it occasionally retains a considerable size in the adult. After the second year it becomes reduced in size, and for the greater part changed into adipose tissue, retaining in general its shape, and containing remnants of its former lymphoid structures.

It is commonly made up of two elongated, nearly equal pyramidal lobes of a

FIG 914.—THYMUS GLAND IN A CHILD AT BIRTH.



greyish-pink colour, which meet each other near the middle line; but they vary in number and are inconstant in size. There may be but a single lobe present, or a third may intervene between the other two. Sometimes the right lobe and sometimes the left lobe is the larger.

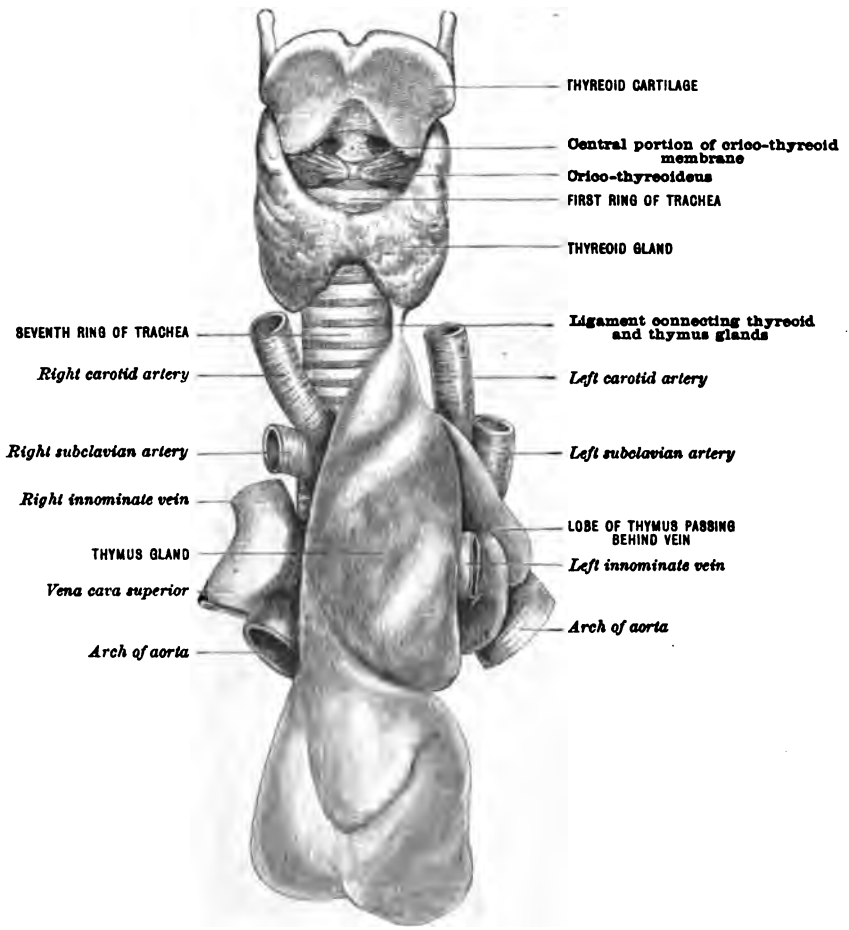
The thymus gland is about 5 cm. in length, about 3·7 cm. in breadth at its base, and 1·6 cm. in thickness. Its weight at birth is about 15 gm.

Relations.—The thymus gland at the period of its fullest development lies

mainly in the thorax, the rounded apices of the two pyramidal lobes extending into the neck for a variable distance, sometimes as far upwards as the thyreoid gland, covered by the sterno-hyoid and sterno-thyreoid muscles, completely hiding the trachea and the carotid sheaths. Below, it descends through the superior into the middle mediastinum, between the pleural sacs and internal mammary vessels as far as the fourth rib cartilages, and lies behind the sternum, the sterno-hyoid, and sterno-thyreoid muscles. The deep surface of the gland is in relation with the pericardium and the larger vessels to which structures it is moulded, presenting a concave impression for the pericardium, and grooves for the pulmonary artery and superior vena cava and innominate veins.

The thin areolar capsule which invests the lobes of the thymus gland extends

FIG. 915.—THYMUS GLAND IN A CHILD AT THE AGE OF TWO YEARS.



upwards in the form of two flattened fibrous bands to be attached to each lobe of the thyreoid gland. These bands are well marked at the period of birth, and seem to act as suspensory ligaments.

Structure.—The lobes of the thymus are divided into numerous small lobules of polyhedral shape, separated by a small amount of loose fibrous connective tissue. The lobules are, however, all united to a cord of adenoid tissue,—the **medullary cord,**—1 to 3 mm. thick, which permeates each lobe in a tortuous manner. The lobules are composed, in the main, of adenoid tissue. Each lobule presents a cortex, which stains more deeply, and a medulla; in the latter are found irregularly spherical structures, composed of degenerated epithelial cells and colloid, and known as *Hassal's corpuscles.*

The vessels.—The **arteries** are derived from the internal mammary and from the superior and inferior thyreoids.

The **veins** join the left innominate and thyreoid veins.

The **nerves** are very minute, and proceed from the sympathetic and vagus.

Development.—The thymus gland has its origin from the entodermal portion of the third branchial clefts, these developing on each side a hollow bud and a nodular thickening of the epithelium. These structures become elongated and grow on each side in a caudal direction, ventral to the lateral thyreoid buds, until they come into relation with the pericardium, when the distal ends of the two buds fuse, and become separated from their place of origin, the original lumen disappearing. The manner of the metamorphosis of these epithelial buds into the definite thymic tissue is a point which is still under discussion. According to the most recently expressed view, the entodermal epithelial buds are of the nature of an epithelial syncytium. In this vacuoles appear, which convert the syncytium into a cellular reticulum. Certain of the nuclei of this syncytial reticulum become smaller, stain more deeply, and become completely separated from the epithelial reticulum, forming lymphocytes which occupy the spaces of the reticulum. Here and there portions of the syncytium undergo a colloid change and form the Hassal corpuscles (Bell). According to this view, the lymphocytes, the reticulum, and the Hassal corpuscles would have an epithelial origin, the blood-vessels, which enter the epithelial origins of the gland from the surrounding mesoderm, with the small amount of connective tissue surrounding them, the capsule of the gland, and the interlobular connective tissue alone having a mesodermal origin. According to other observers, the epithelial buds become, on further development, permeated with mesodermal tissue, which differentiates into adenoid tissue, remnants of the original epithelium remaining as the corpuscles of Hassal (His, Kölliker).

SECTION XII

THE SKIN AND MAMMARY GLANDS

ORIGINALLY WRITTEN BY WILLIAM ANDERSON, F.R.C.S. REVISED AND LARGELY REWRITTEN FOR THE FOURTH EDITION BY

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THE SKIN

THE **integument** or **skin** forms a complete covering for the external surface of the whole body, and serves not only as a direct protection to the deeper structures, but also as an indirect protection, through the termination of the peripheral ends of the sensory nerves making it an organ of sensation. By means of its glands it plays an important part in secretion and excretion, and it is the principal organ for the regulation of bodily heat. It also has a minor rôle as an organ of absorption.

The *surface area* of the skin has been estimated for an adult male of medium size as about 15,000 square centimetres. In *thickness* it varies in different portions of the surface from 0·5 to 4·0 mm., the thickness in any region appearing to be proportional to the amount of pressure or friction to which the parts are habitually subjected. Thus it is thickest upon the dorsal surface of the neck and trunk and on the palms of the hands and the soles of the feet, while on the ventral surface of the trunk and on the dorsal aspect of the hands and feet it is relatively thin. The thickness is subject to great individual variation. The skin is highly *elastic;* it may be stretched to a considerable extent without rupturing, and it will return to its original condition. The *colour* of the skin varies greatly. It may be white, yellow, or black, or any of the shades of these colours, and, according to the colour, the races of mankind have been divided into white, yellow, and black. The colouration is due partly to pigment and partly to the blood within the cutaneous vessels. The amount of pigment varies with race, age, sex, and with exposure to the sun and air. In the white races the skin of the child is a pinkish-white, tending to become dead white in the adult and yellowish in the aged, and it is normally more pigmented in certain regions, such as the axillary region, the scrotum, vulva, mammary areolæ, etc. Moreover, it is subject to physiological and pathological variations.

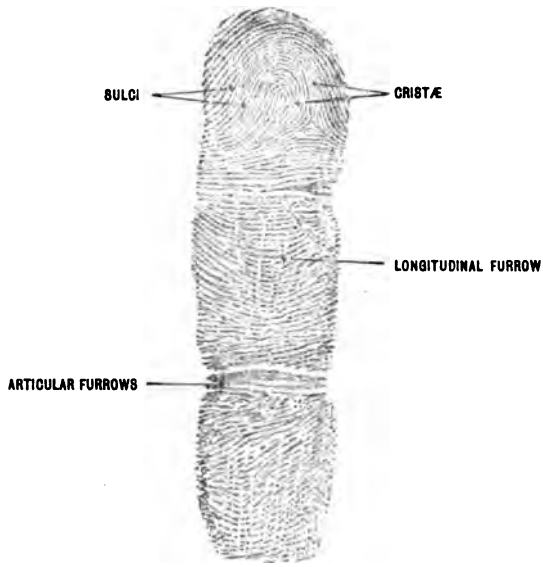
Elevations of a temporary papular character (goose-flesh) may appear upon the external surface of the skin in the positions of the hair-follicles under the influences of cold or emotion, and permanent linear ridges or **cristæ** are present upon the palms and soles and flexor surfaces of the digits. These have an arrangement in definite patterns, which are permanent for the same individual from youth to old age, and the patterns occurring on the palmar surface of the terminal phalanges of the fingers have been so classified as to prove valuable for purposes of identification. Permanent **furrows** or **sulci** separate the cristæ, and over many of the extensor surfaces, such as those of the hand and the wrist, there are numerous fine decussating wrinkles which disappear when the surface is stretched. In the region of the joints there are more marked articular furrows which are much more constant, and are produced by joint flexion. Muscular wrinkles, produced by the contraction of the voluntary and involuntary muscles, and running at right angles to the muscle-fibres, are represented by the lines of expression on the forehead, the transverse wrinkles on the scrotum, and the radiating folds around the anus. A complex wrinkling of the

skin appears in old age, or in the course of exhausting diseases, as a result of loss of elasticity and from absorption of the cutaneous and subcutaneous fat. Rounded depressions called dimples are produced by the attachment of muscle-fibres to the deep surface of the skin, as on the chin and cheek, and are made more evident by the contraction of these fibres, while others are produced by the attachment of the skin by fibrous bands to bony eminences, as the elbow, shoulder, vertebræ, and posterior iliac spines. They are best seen when the subcutaneous adipose tissue is well developed.

Structure of the skin.—The integument consists of the cutis or skin proper, the hairs, the nails, and the cutaneous glands. The **cutis** is made up of a superficial epithelial portion, the *epidermis* (cuticle or scarf skin), derived from the ectoderm, and a deeper connective-tissue portion, derived from the mesoderm, which is divided into *corium* (dermis or cutis vera) and an underlying *tela subcutanea* (subcutaneous tissue or superficial fascia).

The **epidermis** is a non-vascular epithelial layer of varying depth, whose deep surface is moulded over the papillary layer of the corium, while its free surface gives little or no indication of the papillary eminences except in the cristæ of the palms and soles. It presents the openings of great numbers of glands and hair-follicles,

FIG. 916.—FINGER PRINT (NATURAL SIZE) SHOWING CRISTÆ AND SULCI.

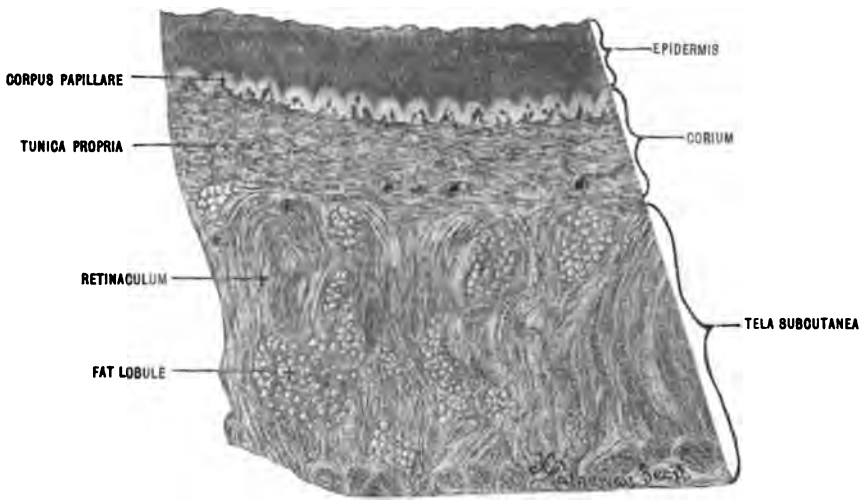


which it lines with tubular prolongations. It consists of epithelial cells of various shapes, and is divided into an outer, harder, drier, lighter layer, the **stratum corneum,** and an inner, softer, moister, darker layer, the **stratum germinativum** (Malpighii). It is in this latter layer that most of the pigment is found—much in the coloured races, a small amount in the white; none, however, occurs in albinos. In many regions still other strata may be recognised. Nerve-fibrils are said to be distributed between the cells of the stratum germinativum, but no vessels exist in any part of the epidermis, and it is for this reason that the surgeon, in skin-grafting, usually includes all the layers of the epidermis and the extreme tips of the papillæ of the corium, as shown by the minute bleeding points left on the surface from which the graft has been cut. The absence of the deeper and more highly vitalised cells in the pellicle separated by a blister is probably responsible for the almost uniform failure of transplantation of this material.

The **corium** is composed of interwoven bundles of connective tissue intermixed with elastic fibres, fat, and scattered unstriped muscle-fibres. It is traversed by a rich plexus of blood- and lymph-vessels and nerves, and encloses hair-bulbs and sebaceous and sudoriferous glands. The superficial layer of the corium, the **corpus papillare,** is of finer structure, free from fat, and forms a multitude of eminences

called **papillæ,** which project into corresponding depressions on the under surface of the epidermis. The papillæ are very closely set, varying from 36 to 130 to a square millimetre (Sappey), and the largest, reaching a height from 1 to 2 mm., are found in the palm and sole and under the nails, while the smallest, from a third to a fourth as large, are upon the face, scrotum, and mammæ. The papillæ are usually simple cones, but some are slightly bulbous at their free ends and others have duplicated apices. Those on the flexor surfaces of the hands and feet are arranged in long, curvilinear ridges, separated from each other by furrows, and two parallel papillary ridges are covered by each crista. Some of the papillæ contain vessels, others nerves, or, in certain situations, a special tactile organ, whence they are known as vascular or tactile papillæ. The deeper layer of the corium, the **tunica propria,** is composed of coarser and less compact fibrous bands intermingled with fat lobules, and passes without any definite line of demarcation into the subcutaneous tissue. The fibrous tissue is arranged, for the most part, in intercrossing bundles nearly parallel to the surface, and those bundles which are parallel to the usual lines of tension of the skin are more tightly stretched, whence it results that wounds of the skin tend to gape most in certain directions. On the scalp, forehead, chin, and epigastrium the bundles cross in all directions, and a round wound appears as a ragged or triangular hole. On the rest of the body the bundles run mainly in one direction, the lines taking

FIG. 917.—THE MUCH THICKENED SKIN OF THE PALM OF THE HAND. (MAGNIFIED SIX TIMES.)



a direction nearly at right angles to the long axis of the limbs, and on the trunk, running obliquely, inferiorly, and laterally from the spine (figs. 918, 919). The arrangement of the vessels of the skin is influenced by the arrangement of the connective-tissue bundles. Unstriated muscle-fibres are scattered through the corium and are collected into bundles in the neighbourhood of the hair-follicles.

The **tela subcutanea** or superficial fascia, which connects the skin to the underlying parts, is so closely blended with the deep surface of the corium that there is no line of demarcation between them. Like the corium, it is composed of bundles of connective tissue containing elastic fibres and fat, but the bundles are larger and more loosely arranged, so as to form connective-tissue septa, and divide the fat into smaller or larger lobules. Where these connecting strands are especially large and well defined, they are known as **retinacula.** Over almost the whole surface of the body the connective-tissue strands are arranged nearly parallel to the surface, and bind the skin so loosely to the parts beneath that it moves freely over the deeper parts, but exceptions to this arrangement are found in the flexor surface of the hands and feet and in the scalp and face, where the connective-tissue bundles of the tela subcutanea run almost at right angles to the surface and bind the skin firmly to the deep fascia.

The quantity of subcutaneous fat varies considerably in different parts of the body. It is entirely absent in the penis, scrotum, and eyelids. When it is abundant,

the subcutaneous layer is known as the **panniculus adiposus.** In some situations, as in the lower portion of the abdomen and in the perineum, the connective tissue is so arranged that the panniculus may be divided into layers, so that a superficial

FIG. 918.—DIAGRAM SHOWING THE DIRECTION OF THE CONNECTIVE-TISSUE BUNDLES OF THE SKIN. (After Langer.)

and a deep layer of the superficial fascia may be recognised. The fat is well developed over the nates, palms, and soles, where it serves as pads or cushions; in the scalp it appears as a single uniform lobulated layer between the corium and the aponeurosis of the epicranial (occipito-frontal) muscle; and on other parts of the surface it is

somewhat unequally distributed and shows a tendency to accumulate in apparent disproportion in some localities, as on the abdomen, over the symphysis pubis, about the mammæ in females, etc. Everywhere except on the scalp it may undergo rapid and visible increase or decrease under the influence of change of nutrition.

FIG. 919.—DIAGRAM SHOWING THE DIRECTION OF THE CONNECTIVE BUNDLES OF THE SKIN. (After Langer.)

Subcutaneous planes of striped muscle are comparatively scanty in man when compared with the great panniculus carnosus of the lower mammalia, and are best represented by the platysma in the neck. Unstriped muscle, which is present in all parts of the corium, as appendages to the hair-follicles, is found only in certain

parts of the tela subcutanea, as in the scrotum and perineum, around the anus, in the papillæ, and beneath the areolæ of the mammæ.

In some situations where the integument is exposed to repeated friction over subjacent bones or other hard structures its movements are facilitated by the development of serosa-lined, sac-like interspaces in the subcutaneous tissue, the **subcutaneous bursæ mucosæ.**

Of these, the most constant are the following:—the **premental subcutaneous bursa,** between the periosteum and the soft parts over the tip of the chin; the **laryngeal subcutaneous bursa,** over the ventral prominence of the thyreoid cartilage of the larynx (often found in the male); the **acromial subcutaneous bursa,** between the acromion and the skin; the **olecranal subcutaneous bursa,** beneath the skin on the dorsal surface of the olecranon; the **lateral epicondylar subcutaneous bursa** (of the humerus), found beneath the skin over the lateral epicondyle of the humerus (occasional); the **medial epicondylar subcutaneous bursa** (of the humerus), between the skin and the medial epicondyle of the humerus (more frequent); the **dorsal metacarpophalangeal subcutaneous bursæ,** between the skin and the dorsal side of the metacarpo-phalangeal joints (occasional, especially the fifth); the **dorsal digital subcutaneous bursæ,** beneath the skin over the proximal finger-joints and rarely over the distal finger-joints; the **trochanteric subcutaneous bursa,** between the skin and the great trochanter of the femur; the **prepatellar subcutaneous bursa,** beneath the skin covering the inferior half of the patella; the **infrapatellar subcutaneous bursa,** between the skin and the superior end of the ligamentum patellæ; the **subcutaneous bursa of the tuberosity of the tibia,** anterior to the tibial tuberosity, covered by skin or by skin and crural fascia; the **lateral malleolar subcutaneous bursa,** between the skin and the point of the lateral malleolus; the **medial malleolar subcutaneous bursa,** between the skin and the medial malleolus; the **calcaneal subcutaneous bursa,** in the sole of the foot between the skin and the plantar surface of the calcaneum.

Blood-vessels of the skin.—The *arteries* enter the skin from the subcutaneous tissue, where they anastomose freely. In the deeper layer of the corium they form a plexus, the *cutaneous rete arteriosum*, from which small branches are given off to supply the fat and sweat-glands and also to the papillary layer of the corium, where another network of arteries is formed, *subpapillary rete arteriosum*. From the subpapillary rete, minute twigs pass to the papillæ, to the hair-follicles, and to the sebaceous glands. In the palms and soles the papillary twigs are given off from the minute branches of the subpapillary rete, which run parallel, without anastomosing, beneath the rows of papillæ. Minute venules arise from the capillaries of the papillæ, and form a series of closely connected plexuses parallel with the surface. Of these *retia venosa*, one is situated just beneath the papillæ, and another at the junction of the corium and subcutaneous tela. They receive branches from the fat, hair-follicles, and glands, and empty into the large veins of the skin, *venæ cutaneæ*, situated in the subcutaneous tissue. The *lymphatics* from the papillæ form a subpapillary network which opens into a subcutaneous network connected with the larger lymph-vessels.

The nerves.—The skin is supplied with numerous nerves, but the number varies in different parts of the body according to the sensitiveness. Towards their termination the nerves branch and rebranch, and just beneath the surface they form a great number of small twigs from which the terminal fibres arise. These may be divided into two groups—those that end freely and those whose termination is surrounded by a capsule. The free ends are slightly enlarged and terminate in the epidermis and in certain regions in the corium. The encapsulated terminations form special end-organs of touch and are divided into the *bulbous corpuscles* (end-bulbs of Krause), the *lamellous corpuscles* (corpuscles of Vater, Pacinian corpuscles), *tactile corpuscles* (corpuscles of Meissner), *genital corpuscles*, and the *articular corpuscles*. All the terminations are microscopic, not exceeding 0·2 mm. in length, with the exception of the lamellous corpuscles, which may be about 2 mm. long and half as thick.

THE APPENDAGES OF THE SKIN

The **hairs or pili** are a special differentiation of the skin. They cover nearly the entire surface of the body with the exception of the following regions:—the palms of the hands; the soles of the feet; the dorsal surface of the distal phalanges of the fingers and toes; the red borders of the lips; the glans and inner surface of the prepuce of the penis; the inner surface of the labia majora; the labia minora; and the papillæ of the mammæ. In certain situations the hair is especially long and large, as upon the scalp, in the axilla, and, after puberty, upon the face in the male, and in the pubic region in both sexes. The pubic hair extends upon the external genitalia and upon the ventral abdominal wall towards the navel. Strong, well-developed, but shorter hair is also found in the eyebrows, the eyelashes, at the entrance to the external acoustic meatus, and at the nares. Upon the extensor surfaces of the extremities and upon the chest in adult males the hair is also longer and stronger than upon the rest of the body, where it is short, fine, and downy, as it usually is in all situations in the fœtus, and is called **lanugo.** In colour, the hair is either white, grey, red, brown, or black, or variations of these colours, and it may be straight or

curled. The size, length, colour, and curliness of the hair vary greatly, not only in the different races, but also with the individual.

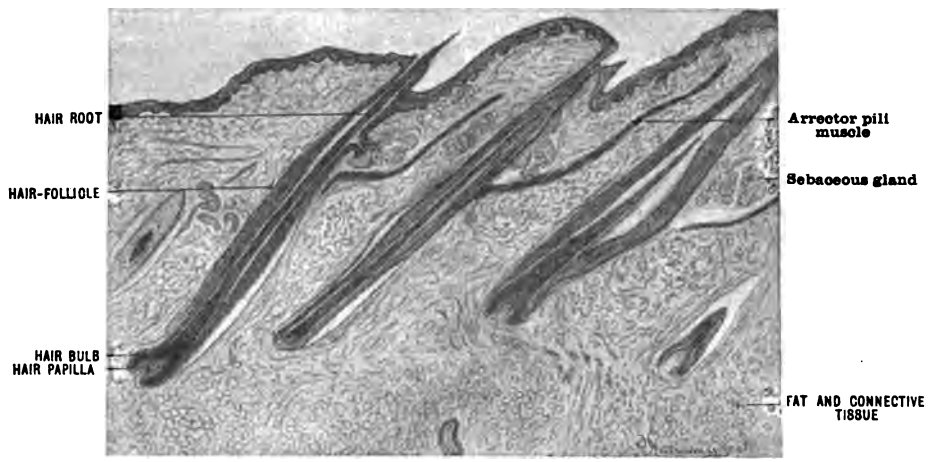
Each hair consists of a shaft above the surface of the skin and a root, imbedded in the skin. The down-growth of skin which surrounds the root constitutes the **hair-follicle,** and at the bottom of the follicle a vascular papilla, the **hair papilla,** projects into it. This is capped by the expanded end of the root, forming the **bulb.** The root passes without line of demarcation into the shaft, the free end of which, unless cut or broken, is conical. In straight hair the shaft is round or oval in cross-section, but it is more flattened in curly hair.

The hair-follicles are oblique or curved, so that the hair-shafts stand at an oblique angle with the surface of the skin, and are arranged in more or less definite tracts, forming the hair-streams, **flumina pilorum,** which have a definite direction for a given region and tend to be constant. In certain places the follicles are arranged around a centre, forming the **vortices;** thus they point away from the top of the head and towards the umbilicus.

The hairs are constantly being shed and replaced, a new hair appearing in the old follicle. In the aged there is a loss of pigment in the hair, and those that are shed are frequently not replaced.

Many of the hairs have connected with them bundles of unstriped muscle-fibres.

FIG. 920.—VERTICAL SECTION OF SKIN FROM SCALP TO SHOW STRUCTURE OF HAIR. Magnification 20 diameters.

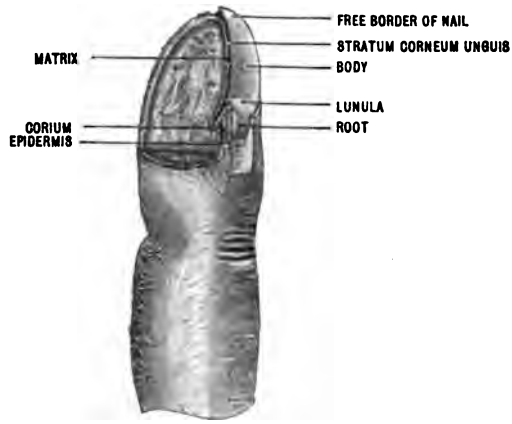


These are the **arrectores pilorum.** They are more oblique than the hair-follicle, and are attached to it in the obtuse angle between the follicle and the surface of the skin, their other end being joined to the papillary layer of the corium. In the triangle between each hair-follicle and its muscle and the skin are the sebaceous glands. The contraction of the arrectores pilorum not only causes the hair to become more vertical, but it also helps to empty the sebaceous glands.

The **nails** or **ungues** are thin, semitransparent epidermic plates upon the dorsal surface of the distal phalanges of the fingers and toes. Each consists of a distal exposed part, the **body,** and a proximal covered part, the **root,** from which the growth proceeds. The root thins out proximally and ends in a convex sharp margin, and the body ends distally in a free border, which overhangs the tips of the fingers and toes and tends to become long and claw-like, unless broken or cut. The dorsal surface of the nail is convex from side to side, and is formed by a thickened, horny layer, corresponding to the deeper part of the stratum corneum and known as the **stratum corneum unguis.** It ends on each side in a somewhat thinned border, which, as well as the root, is overlaid by a fold of skin, the **vallum unguis,** and is fitted into a depression between the vallum and the matrix. The concave volar or plantar surface is softer and corresponds to the deeper layers of the stratum germinativum (Malpighii) of the skin. It rests upon the corium, here termed the

matrix unguis, and made up of a dense felt-work of connective-tissue fibres which is highly vascular and sensitive and strongly binds the nail to the dorsal surface of the terminal phalanx. The papillæ of the matrix are arranged in strongly marked longitudinal ridges, the **cristæ of the matrix.** Due to its transparency, the blood in the matrix is seen through the body of the nail, and gives to it a pink colour, but at the junction of the body and the root there is a semilunar area, the **lunula,** which is less transparent and therefore lighter in colour.

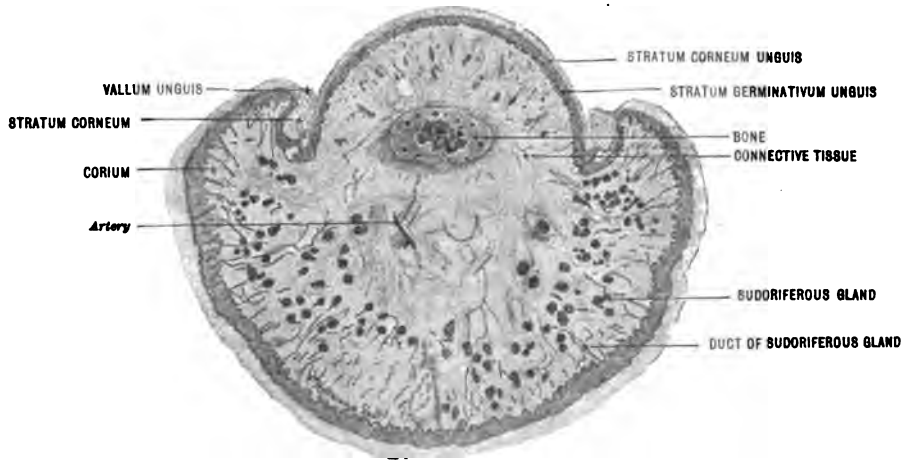
FIG. 921.—LONGITUDINAL SECTION OF THE RIGHT INDEX-FINGER AND NAIL.



The **glands** of the skin are of two kinds, *glomiform* and *sebaceous.* The **glomiform glands** include the ordinary sweat-glands and also modifications of these which are found in certain regions.

The **sudoriferous glands** (sweat-glands) are simple tubular glands, which are found in the skin of almost the entire body. The terminal secreting portion is coiled, forming an elliptical mass surrounded by connective tissue, non-striated muscle-fibres, and a capillary network, and is situated in the corium or in the underlying

FIG. 922.—TRANSVERSE SECTION OF THE FINGER OF A NEWBORN CHILD. (Magnified twelve times.)



tela subcutanea between the fat-lobules. The excretory duct passes in a straight direction through the corium, but has a spiral course through the epidermis, and opens by a funnel-shaped opening, the *sudoriferous pore,* which is distinctly visible to the naked eye upon the surface of the skin. The sweat-glands are most numerous in the palms and soles, where they pass between the papillary ridges of the corium to open on the summit of the cristæ cutis; they are least numerous on the dorsal

surface of the neck and trunk and on the lower limbs. Sappey estimates the total number over the whole body at 2,000,000.

The **ciliary glands** (glands of Moll) are modified sudoriferous glands of the branched tubo-alveolar type. They are situated in the eyelids near the free border, and open into the follicles of the eyelashes (p. 1046).

The **circumanal glands** are found in the circular area, about 1·5 cm. wide, which surrounds the anus a short distance from it. Several types of glands are found here —ordinary sweat-glands, sweat-glands two or three times as large as the ordinary sweat-glands, and tubo-alveolar glands. The large sweat-glands are also found in the axilla.

The **ceruminous glands** are modified sweat-glands of the branched tubo-alveolar type, found in the external acoustic meatus (p. 1052).

The **sebaceous glands** are distributed over nearly the whole surface of the body, being closely associated with the hairs, into the follicles of which they empty. They are absent from the palms and soles and from the red borders of the lips. In a few situations they open independently of the hair-follicles, and are then usually much modified, as at the angles of the mouth, on the labia, and on the glans and prepuce of the clitoris, where they are very small and few in number, on the glans and prepuce of the penis, where they are known as preputial glands, and in the eyelids, where they form the tarsal (Meibomian) glands. The wide excretory duct opens, as a rule, into the upper third of the hair-follicle, and towards its base it widens and is connected with a number of single or branched oval alveoli which are surrounded by a connective-tissue sheath connecting them to the hair-follicle. There may be from one to six glands to each hair, but the number and size are independent of the size of the hair. They vary but little in size; the largest are found on the external surface of the nose. The secretion is formed by the breaking down of the cells of the gland.

THE MAMMARY GLANDS

The **mammæ** or mammary glands are cutaneous glands functionally closely associated with the reproductive organs, and, in the female, subjected to marked changes at puberty, during pregnancy and lactation, after lactation, and at the menopause, but in the male remaining rudimentary and functionless throughout life.

They are composed of glandular tissue, imbedded in the superficial fascia, and fat, and covered by skin. In the human species there are normally two. Each well-developed gland, as it occurs in the female, forms a firm, elastic, hemispherical, or somewhat conical elevation on the ventral surface of the thorax. It extends from the second or third to the sixth or seventh rib, and from the edge of the sternum to the fold of the axilla, with processes projecting somewhat beyond these limits. The skin-covered ventral surface is smooth and convex, and passes superiorly, without sharp demarcation, to the ventral surface of the thorax, but laterally and inferiorly is usually more sharply defined (fig. 923). It is most prominent slightly below the centre, and at this point there is a small, wart-like projection, the *papilla*, or nipple, surrounded by a pigmented area of skin, the *areola*.

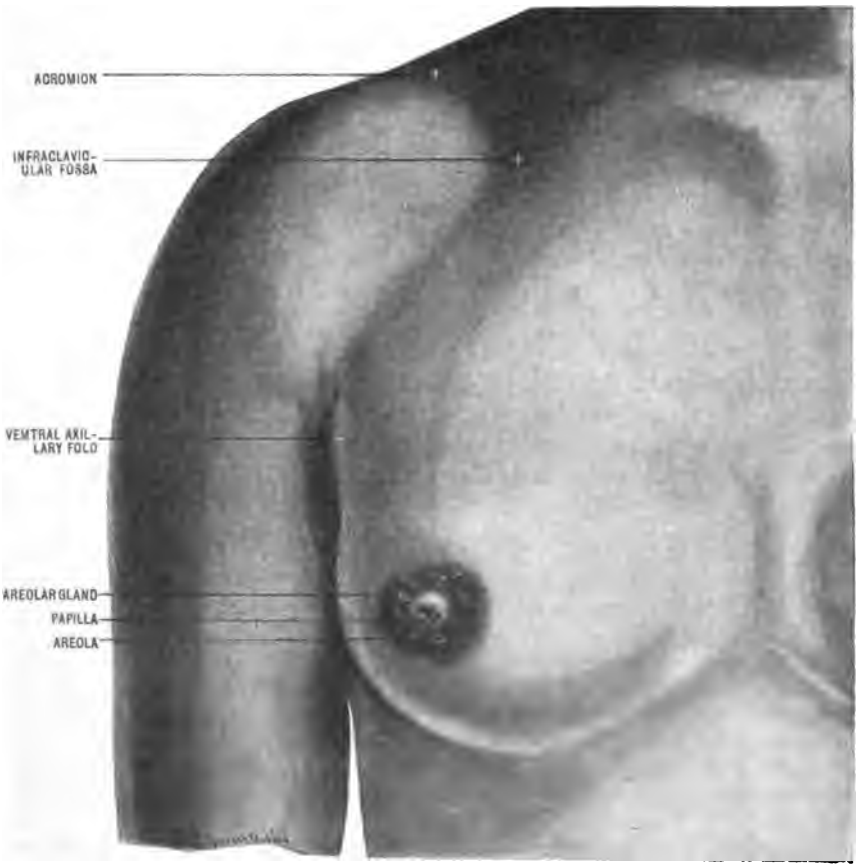
The dorsal surface is concave, and is in relation in its superior medial two-thirds with the fascia over the pectoralis major. In its inferior lateral third it overhangs the axillary fossa, and is in relation with its lymphatic glands and with the serratus anterior muscle, and at its most inferior part, with the external abdominal oblique.

Structure.—Each mamma is composed of from fifteen to twenty somewhat pyramidal **lobes,** arranged with their bases towards the periphery and their apices towards the papilla. The lobes are subdivided by a considerable amount of connective tissue into smaller divisions, the **lobules,** which are in turn made up of acini, and are bound together by connective tissue to form a flattened circular mass. The uneven ventral surface of this mass presents numerous irregular pyramidal processes which project towards the skin and are connected to it by strands of connective tissue, the retinacula cutis, the spaces between the processes being filled up with connective tissue and fat. The concave dorsal surface is much smoother, and is bound to the pectoral fascia by loose connective tissue containing a small amount of fat. Minute

processes of glandular tissue project into this retromammary tissue, some of them accompanying the septa of the pectoral fascia between the bundles of muscle-fibres. The circumference of the mamma is thick and well defined, but presents numerous irregular processes. One well-marked projection extends superio-laterally into the axillary fossa, and there are frequently, also, two other less marked projections, one extending medially towards the sternum and the other inferio-laterally. The connective-tissue stroma which surrounds the lobes and lobules is continuous with the superficial fascia, and its fat gives the smoothness to the surface of the breast. There is no fat immediately beneath the areola and nipple.

When the fat is absorbed, as it is during lactation or in emaciation, the lobules stand out much more distinctly. Each lobe has a single excretory duct, the **lactiferous duct,** which breaks up into smaller and smaller branches as it is traced

FIG. 923.—RIGHT MAMMA OF A GIRL EIGHTEEN YEARS OLD. (Modified from Spalteholz.)



from the papilla peripherally to the lobules and acini, and presents beneath the areola an irregular, spindle-shaped dilatation, the **lactiferous sinus** or **ampulla.** It then contracts, turns ventrally, and passes, parallel with the ducts from the other lobes, to its opening at the summit of the nipple. There is no connection between the ducts of the different lobes.

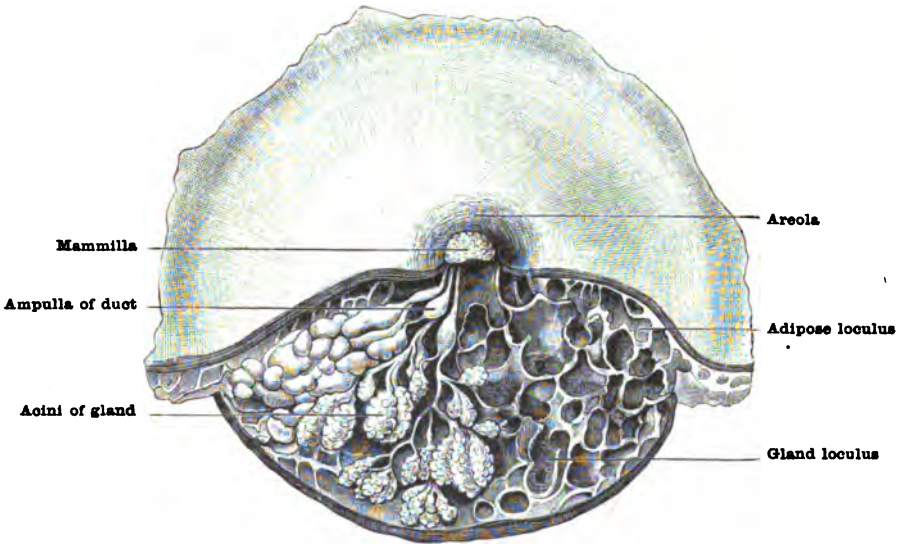
The **papilla** or **nipple** forms a projection slightly below the centre of the ventral surface of each mamma. Its position in reference to the chest-wall varies greatly with age, sex, and individual, but it is usually opposite the fourth or fifth rib. It is of variable shape, conical, hemispherical, discoidal, or slightly pedunculated, and is covered with a thin, wrinkled, pigmented skin the corium of which has many large papillæ. Beneath the skin, near its base, there are well-developed sebaceous glands, but there are no sudoriferous glands nor hair-follicles. The rounded fis-

sured apex of the nipple has fifteen to twenty minute depressions into which the lactiferous ducts empty, and close under the skin is a thin layer of unstriped muscle which sends numerous interlacing fibres around the lactiferous ducts as they pass through the nipple, and by their contraction cause the nipple to become firmer and more projecting.

Over the **areola** the skin is thin, delicate, and pigmented. Its under surface is devoid of fat, but contains a layer of muscle-fibres continuous with those of the nipple. The colour of the areola in a nullipara is rose pink, the shade varying with the complexion, but during pregnancy it darkens—slightly in blondes, but so as to become almost black in brunettes. After lactation but little pigmentation remains in the former, considerable in the latter. During pregnancy there is sometimes seen around the areola an irregular, slightly pigmented ring, the *secondary areola*. The ventral surface of the areola is roughened by a number of slight elevations caused by rudimentary milk-glands, **areolar glands (glands of Montgomery)**, which enlarge greatly during pregnancy, and produce a slight secretion which escapes from the ducts which empty upon their summits. They are also found in the secondary areola.

The **male breast** is a small flat disc from 1 to 3 cm. in diameter. It does not

FIG. 924.—THE FEMALE MAMMA DURING LACTATION. (After Luschka.)



develope beyond the condition attained at birth, except for an increase in size corresponding to the general body growth. It presents a small conical nipple surrounded by a red or brownish areola, but the position of the nipple is even more variable than in the female.

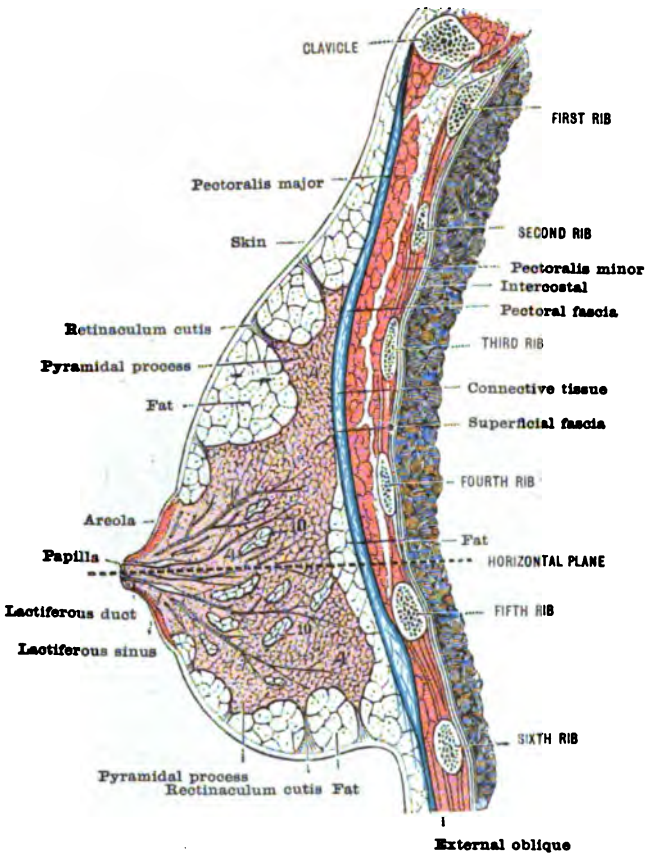
Changes due to age and functional activity.—At *birth* the mamma consists mainly of ducts, and is about one centimetre in diameter. Nevertheless, within the first few days it may secrete a few drops of milk, the so-called 'witches' milk.' From birth until puberty the mamma remains rudimentary, simply keeping pace with the general body growth, but in the female, *at puberty*, an abrupt change occurs. The branching tubules become much more complicated, and some acini appear; the stroma and fat are also greatly increased; and the breast becomes well formed and measures 10 to 12 cm. in diameter, and 5 to 6 cm. in thickness, but consists mainly of fatty stroma and ducts, with but a small amount of gland tissue. During *pregnancy* it increases in volume two or three times. This is due to the increase in the size and number of the lobules and acini, and is accompanied by a decrease in the interlobular and superficial fat, so that the gland feels hard and uneven. *After lactation* the gland decreases nearly to its original size, the decrease being due to an involution of the parenchyma, the acini being reduced to narrow tubules, many of them atrophying. With this is associated a development of fat in the stroma. The gland does not, however, regain its virgin appearance, its main mass becoming loose, irregular, and less distinct; the peripheral processes larger; while the stroma contains numerous fat-lobules. This causes the breast to be less smooth, firm, and elastic, and it tends to become pendulous and form a sulcus where it overhangs its base. After lactation the skin, due to stretching, is often marked by bluish-white striæ. With the *end of sexual activity* the secreting portions of the glands

gradually atrophy, finally leaving little more than the ducts; the main mass of the gland is represented only by a flattened disc, and the peripheral processes can scarcely be made out. In fat women there may be little reduction in size, but the breast is composed almost entirely of fat.

Variations.—The female mammæ vary greatly in size both with race and individual. They are seldom equal, the left being usually the larger. A breast may be made up of a large amount of stroma and a small amount of glandular tissue, or the reverse, and therefore a small breast may furnish more milk than a large one. In emaciation the breast becomes flat and disc-shaped, with an irregular surface, but in a well-nourished adult nullipara it is somewhat conical, due to the relatively large amount of glandular tissue, and with increasing stoutness becomes hemispherical, due to the increase in circummammary fat. After several periods of nursing the breast may become soft and flabby, and very pendulous, and overhang its base to a considerable extent.

Complete absence of both mammæ, *amastia*, is an extremely rare anomaly, and is usually associated with other defects. Complete absence of one is slightly less rare. A more frequent condition is arrest of development, leading to a rudimentary and functionless organ. Absence of the nipple, *athelia*, is much commoner, and all gradations of defects are found between complete absence and perfect nipples. Increase in the number of mammæ, *polymastia*, and nipples,

FIG. 925.—SAGITTAL SECTION OF THE RIGHT MAMMA OF A WOMAN TWENTY-TWO YEARS OLD. (Testut.)

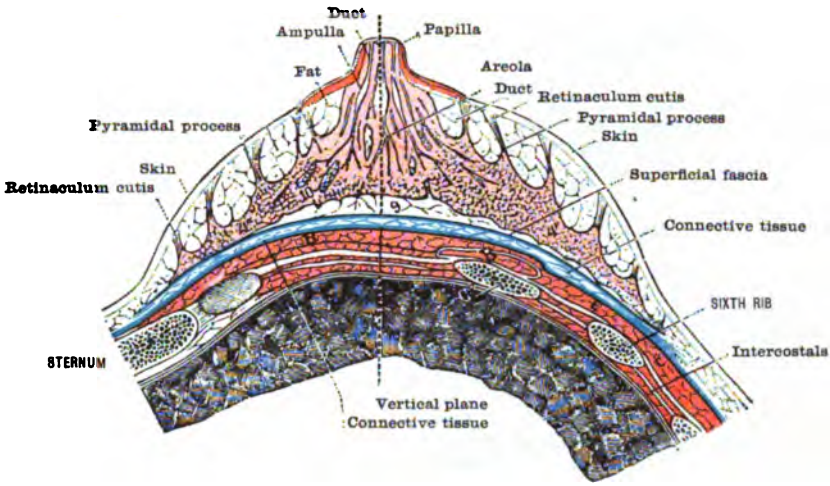


polythelia, is much more common. They may be found on either side, usually along a line extending from the axillary fossa to the genitalia, corresponding to the position in which they occur in other mammals and also to the milk line of the embryo. They occur occasionally in other regions, but in a large proportion of cases they occur on the thorax, inferior and medial to the normal glands. These supernumerary structures may be represented only by a pigmented area or by a nipple with or without an areola; by a gland with a more or less perfect nipple and areola, or with ducts opening without a nipple, or there may be no opening on the surface. There may be two nipples on one areola, or two on one breast with separate areolæ. Polymastia occurs more often on the left, amastia on the right, side. The extra mamma is very rarely perfectly developed and functional. Both the above conditions occur in both male and female.

Vessels and nerves.—The **arteries** are derived from the internal mammary (p. 554), the lateral thoracic (p. 560), the intercostals (p. 583), and the pectoral branch of the thoraco-acromial. These vessels anastomose freely and form a wide-meshed network around the acini, and from the arterial capillaries venous capillaries arise and pass to the ventral surface of the gland to form a loose network beneath the skin. During lactation these subcutaneous **veins** show through the skin as bluish lines, and frequently form a more or less complete circle around the nipple. They

connect with the superficial veins of the neck superiorly, with those of the abdomen inferiorly, and with the thoraco-epigastric vein laterally. They carry the blood to larger vessels, which empty into the subclavian, the intercostal, the internal mammary, and the axillary, and they may connect with the external jugular and femoral veins. The **lymphatics** of the mammæ are very numerous. They form rich plexuses and anastomose freely. They communicate with the lymphatics of the skin, the ventral chest-wall, and those of the deep fascia over the pectoral muscles, as well as the lymphatics of the opposite side. Two or three large vessels pass directly to the axillary lymphatic glands. The mammary lymphatics also empty into the lymphatics which accompany

FIG. 926.—HORIZONTAL SECTION OF THE RIGHT MAMMA OF A WOMAN TWENTY-TWO YEARS OLD. (Testut.)



the blood-vessels of this region, and thus communicate with the axillary, subclavicular, and supraclavicular lymphatic nodes. Moreover, those from the medial portion of the gland accompany the branches of the internal mammary artery and empty into the sternal glands within the thorax.

The **nerves** to the mammæ are the sympathetic, the second, third, fourth, fifth, and sixth intercostals, the supraclavicular branches from the cervical plexus, and also possibly branches from the brachial plexus.

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(*Note:—It is not possible in this space to give a thoroughly representative illustration. That shown is one of a series depicting—according to Professor MacCallum, of Johns Hopkins University—the fact that the heart may be considered as three flat bands.*)

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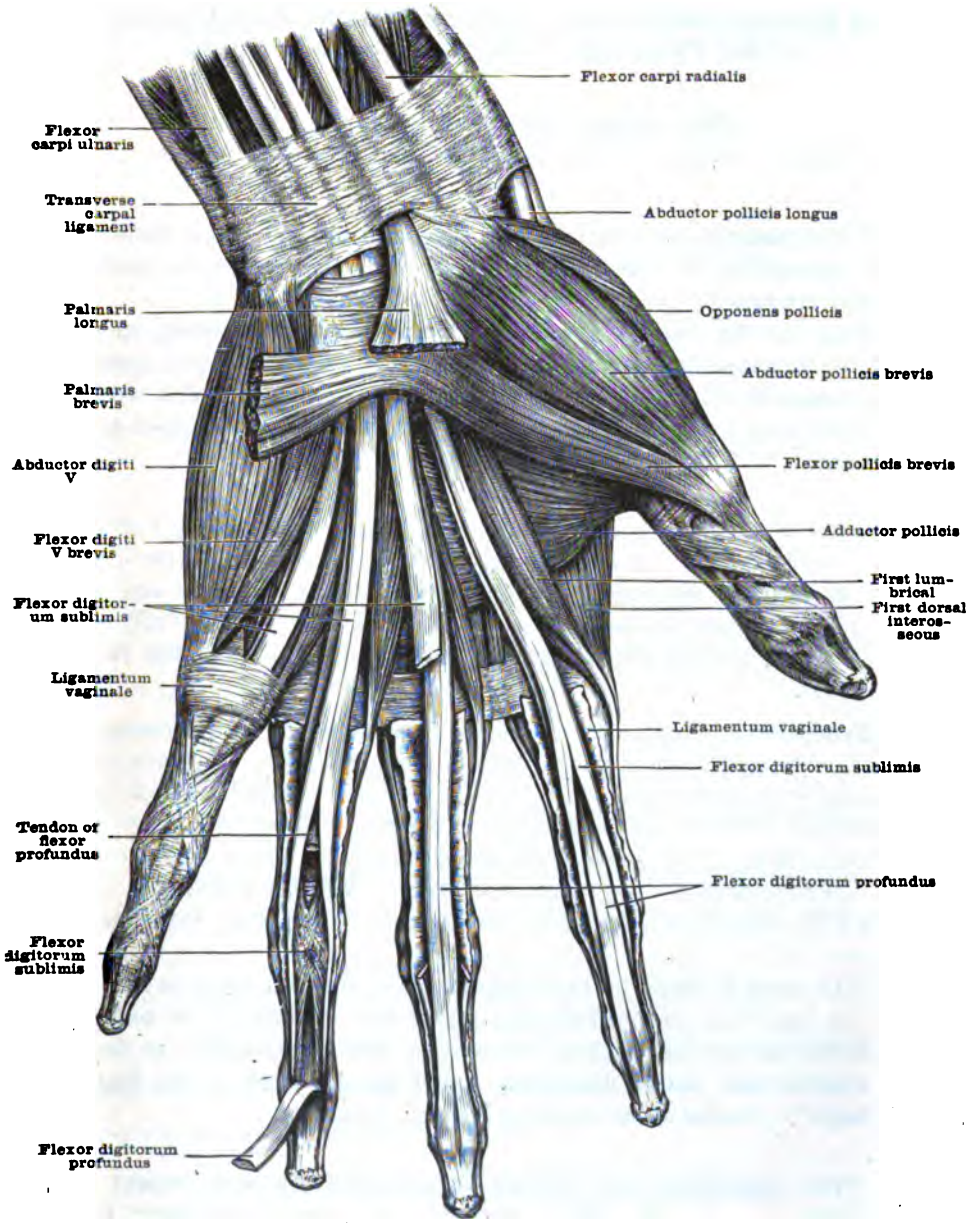

FIG. 336.—**THE SUPERFICIAL MUSCLES OF THE PALM OF THE HAND.**

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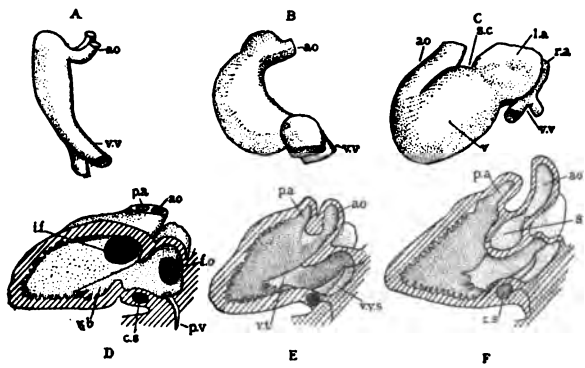

FIG. 159 (*Reduced*).—EMBRYONIC HEARTS.

A *and* B, *from Rabbits* 9 *days after coitus,* C, *from a human embryo of* 3 (?) *weeks;* D *and* E, *from a* 12 *mm. pig* (D *sectioned on the left of the median septum, and* E *on the right of it);* F, *from a* 13.6 *mm. human embryo, sectioned like* E.

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Synopsis of Contents: PART I.—*General Development: The Spermatozoon and Spermatogenesis; the Ovum and Its Maturation and Fertilization; the Segmentation of the Ovum and the Formation of the Germ Layers; The Development of the External Form of the Human Embryo; The Medullary Groove, Notochord, and Mesodermic Somites; The Yolk-stalk, Belly-stalk, and the Fetal Membranes.* PART II.—*Organogeny: The Development of the Integumentary System; Connective Tissues and Skeleton; Muscular System; Circulatory and Lymphatic Systems; Digestive Tract and Glands; Pericardium and Pleuro-peritoneum, the Diaphragm and the Spleen; Organs of Respiration; Urinogenital System and the Suprarenal Bodies; Nervous System; Organs of Special Sense; Post-Natal Development; Index.*

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Professor of Histology and Human Embryology, Harvard University Medical School.

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Professor of Zoology in West Virginia University.

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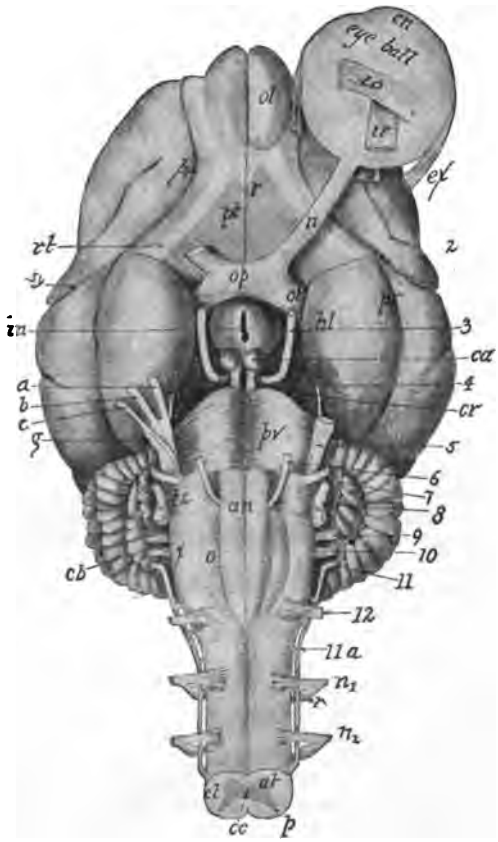
Professor of Biology in Lafayette College.



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[B N A]

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